ENGINEERING CASE LIBRARY

ECL 133A

HERON ROAD BRIDGE (A)

On August 10, 1966 one of the spans of the Heron Road Bridge in Ottawa collapsed during pouring of the deck, carrying nine persons to their deaths and causing injury to many others. This case presents the story of the collapse and the subsequent investigation as recorded in the press and trade journals. This case focuses on engineering aspects of the tragedy and many human interest aspects have had to be omitted. It is hoped that the lessons to be drawn from this case will help prevent future tragedies of this kind.

HERON ROAD BRIDGE (A)

DISASTER

August 11, 1969
from Citizen

8 Dead, 57 Injured in Heron Road Disaster

A huge section of the new Heron-Baseline Bridge flipped like a giant teeter-totter, collapsing the southern span of the structure, turning the west bank of the Rideau River into a grim steel and concrete coffin. Screaming workmen were crushed by huge blocks, buried alive in wet cement and skewered on steel reinforcing rods in the worst construction accident in Ottawa's history.

No one knows why–yet.

from Journal

Eight men are dead. At leat 56 workers were hurt badly enough to warrant hospital treatment–14 of them critically. At least 15 of the injured were pulled broken, bleeding and bruised–but still alive–from the wreckage. The concrete that pinned them weighed a thousand tons. All workmen have been accounted for.

The bomb-like crash was strong enough to be recorded on the Dominion Observatory seismograph at exactly 3:27 p.m. An Observatory spokesman ruled out earthquake as cause of the collapse.

In seconds, the quiet, tree-lined gorge echoed with the screams of the injured and the first frantic shouts of the rescuers. First rescuers were dazed survivors who scrambled back into the rubble to tug with their bare hands at drying concrete and trapped fellow workers. Then came picnickers from nearby Vincent Massey Park, workers from nearby construction sites and astounded motorists from Col. By Drive. Confusion reigned in the early moments. There seemed to be no directors, just many, many helpers, smeared with drying concrete, clothing torn, panting and sweating. Small bands of rescuers stumbled over the rubble scratching with bare hands wherever they heard a moan or saw a human limb.

Some of the most seriously injured were locked in hardening concrete or trapped in webs of steel rods. Jackhammers, blowtorches and heavy wire cutters were needed to free them. The buried seemed scattered in clusters of two and three. The rescue team beside the pillar nearest the river worked tirelessly in the shadow of death. Fifty feet above a truck-sized lump of soft concrete dangled precariously from the top of the pier.

from Citizen

Claude Zekeman was a witness; here is what he heard and saw: "I wasn't an eye witness to the tragedy as much as I was an ear witness. My wife, three daughters, and I were standing at the far end of the Vincent Massey Park picnic grounds listening to a rock 'n roll band with a group of other people. Then, it didn't make much noise, it sounded like a jet plane. People started turning their heads and when I looked all I could see was a cloud of dust. It was about 350 feet away; we were as close to it as anyone at the picnic. I rushed over and when the dust cleared I saw that a big part of the bridge had fallen into the gulley and hole between the Ottawa River and the hills. There was a little debris in the river, but not much. When I got closer, I counted 14 bodies in the wreckage either dead or waiting for some help to come. I have never seen anything like it before; I don't care to see anything like it again."

from Citizen

Bernard Cammie was picnicking at Vincent Massey Park when the Heron Bridge collapsed. He describes the first scenes of horror and confusion:

"I was less than a minute away when I heard a loud crumbling noise; the next thing I heard was someone yelling, 'the bridge has collapsed.' My first thought was to get over there and see what had happened and if I could offer any help. When I arrived, I was on the opposite side of the scene and could see a number of construction workers standing there. They apparently did not seem to realize the extent of the damage or that anybody had been injured. There was only one man standing there screaming and waving his arms to give him a hand. He kept yelling, 'come on, come on, we need help.' I had a pair of soft shoes and couldn't get up the debris. The construction workers, nearly 20 of them, all managed to reach the top and started to clear away the rubbish. There were so many injured; they were being carried on boards and laid out on a clearing until the ambulances arrived. I was there only 10 minutes and it looked like a bomb had just exploded. There was blood all over; it was horrible."

from Journal

Crane operator Paul Tasse had been pouring concrete from the bridge roadway since 7 a.m. When the accident came, he had poured about 250 cubic yards in 3/4 yard buckets and was looking forward either to his 4 p.m. quitting time or some nice overtime. He had just 50 yards of concrete left to pour; the roadway would have stretched from Colonel By Drive to the edge of the Rideau River.

"I had my mind on the next bucket of concrete but I saw it all," he said. "The columns swayed and the whole thing came down." His helper, Gaeton Lacroix, was cleaning the deck of the crane, which was working about 10 feet from the collapse.

"I heard a crack and turned around," Tasse said. "The piers (concrete columns) seemed to swing west for about a second, then everything stopped and collapsed. I saw blood all over flying out from everywhere. Everyone was running to the hill to the men. I ran up to the construction shack to call an ambulance. Then I ran back down to help. I helped about 10 - 15 men to safety. Some could walk, some were in shock and had to be carried. Most were carried out on sheets of plywood. I watched them dig out three dead men from under the east column. The men were crying and screaming and shouting."

The two men are employees of Hurdman Construction Company. Vice-President Fraser Hurdman said his firm rented two hoist cranes to Gaffney Construction for use in concrete work.

"Today's pour was the first and it was just about finished when the accident happened," said Mr. Hurdman. "We were pouring three hundred yards of concrete."

from Report

BACKGROUND

The Heron Road Bridge will span the Rideau River, Colonel By Drive and the Ridcau Canal as part of the extension of Heron Road (Exhibit I).

The City of Ottawa retained the firm of M. M. Dillon & Company Limited, Consulting Engineering of Ottawa, Ontario, to design and supervise the construction of the Heron Road Bridge project.

The proposed design requires the construction of two separate 3-lane concrete bridges of seven spans each. The total length of each structure is 877 feet 6 inches center to center of abutment bearing and comprises five intermediate spans of 147 feet 6 inches plus two end spans, one of 52 feet 6 inches at the west abutment and one of 112 feet 9 inches at the east abutment. The general arrangement of the bridge is shown on Plate 2.

The abutments and piers N1 and S1, N2 and S2, and N3 and S3 are supported on steel H-piles driven to rock. Piers N4 and S4 are bearing directly on bedrock, whereas piers N5 and S5 and N6 and S6 are supported on spread footings founded on dense granular material in the bed of the Rideau River.

The superstructure of the bridge has been designed as a determinate structure, which means that moderate differential settlements of the piers do not induce additional stresses in the structure. A balanced cantilever design has been used for the bridge proper (Exhibit II). This is an arrangement whereby every other span is continuous over two supports, the intermediate spans being comprised of two cantilever sections and a simple suspended span. The entire deck and beam construction is composed of prestressed concrete. The continuous spans, including the cantilever sections, are of post-tensioned hollow concrete box construction which requires that they be constructed in their final location. The suspended spans are of composite construction using precast pretensioned AASHO Type III I-beam and a cast-in-place deck slab.

The cast-in-place post-tensioned sections are designated as PT1N, PT1S, PT2N, Etc., PT meaning post-tensioned and the 1N, 1S, etc., indicating the particular location of the span in the north and south bridge respectively. The pretensioned composite spans are designated SS1N, SS2S, etc., SS standing for the term "simply supported."

Because of the necessity to cast the post-tensioned sections, the PT spans, in their final location, it was necessary for the contractor to provide formwork and a suitable supporting structure to sustain all construction loads, including the weight of the formwork itself, reinforcing steel, wet concrete, construction equipment, plus various live and dynamic loadings to which this structure could have been subjected.

The cast-in-place sections PT3N and PT3S, spanning between piers N4 and N5, and S4 and S5 respectively, required higher falsework than any of the other post-tensioned spans.

A contract was signed on February 12, 1965, between the City of Ottawa and Beaver Construction (Ontario) Limited for the construction of footings for the twelve bridge piers and construction of a retaining wall at the west bank of the Rideau Canal. The work was completed during June 1965.

The bridge structure contract was awarded to O. J. Gaffney Limited on September 21, 1965. The work under this contract consisted of the construction of reinforced concrete pier stems, abutments and pedestrian access stairs, as well as prestressed concrete decks for two 3-lane bridges, each approximately 900 feet long.

Work commenced in the fall of 1965 and proceeded in an orderly fashion. The site records show that no undue difficulties were encountered in the completion of the pier shafts and abutments.

Construction was started at the west end of the project and proceeded in an easterly direction. Spans PT1N and PT1S were constructed during the winter of 1965-66 and by August, 1966 spans PT2N and PT2S were essentially complete and self-supporting. Falsework was in position for spans PT3N, PT3S, PT4N and PT4S.

The post-tensioned sections were planned to be constructed in four separated concrete pours each. Initially, the bottom slabs of the hollow boxes were to be poured in two stages with a construction joint at mid-span between piers. Next, the webs, diaphragms and top slabs were to be placed similarly in two pours with a temporary bulkhead installed at mid-span.

At the time of the accident the bottom slab had been in place over the entire area of PT3N and PT3S for about a month's time. Concrete was being placed for the webs, diaphragms and deck slab on the easterly half of PT3S. The last pour had been started at mid-span at approximately 7:30 a.m. and concreting had progressed to a point some 15 to 20 feet east of pier S5 when the failure occurred at 3:30 p.m. (Exhibit II).

The contractor, O. J. Gaffney Limited, had elected to use a timber structure for the falsework supporting the post-tensioned sections of the bridge. With few exceptions, the design of the falsework was identical for all spans, the height thereof being the only variable from one span to the next. Basically, the falsework for spans PT3N and PT3S were of similar construction.

The job records show that the design underwent considerable modification in the process of obtaining approval from the consultants, partly to satisfy the wishes of the consultants from a structural design point of view, and partly because of site conditions being at variance with those assumed in the original design.

from Citizen

INQUIRY

Ontario Deputy Labour Minister, Thomas Everly, has announced a full-scale inquiry into the disaster.

Keith Cleverden, assistant director of the Ontario Labour Department's construction safety branch, flew into Ottawa within hours of the accident. He began immediate talks with the Province's chief construction safety expert in Ottawa, Robert Kerr, and with other local authorities.

Deputy Labour Minister Everly termed the disaster the worst in Ontario in his 20 years experience and possibly the worst ever. Ontario supervising Coroner, H. B. Cotnam, will be in Ottawa tomorrow to take charge of the investigation. Sources at Queens Park said he had been called from summer holidays at his cottage near Killaloe to conduct "a major inquiry into every aspect of this disaster." James McNair, chief engineer of the province's safety construction branch, was also travelling to Ottawa to take part in the probe.

The reasons the bridge span collapsed were varied. The shoring support in the span was blamed by Bill Blair, representative of Labourers International Union of North America. Green wood used in the shoring is more flexible than dry wood and not strong enough to support the weight of fresh concrete. Mr. Blair also criticized the speed used in construction business to meet contract deadlines.

Watch Word Accompanied with Safety

from Citizen

Safety was the watch word of O. J. Gaffney Limited, general contractors at the collapsing Heron Bridge. "Safety, safety, safety, that's all we hear around here every morning since construction began. We have had a 100% safety record during the six years we have been a company and they were very strict on us. We couldn't work on a platform 5 feet off the ground for 5 minutes unless we first installed railings." Oliver Gaffney, President of the company, flew to the disaster site from Toronto. "I have no idea what happened."

Cause Unknown

from Journal

A hastily called press conference at city hall today shed little light on why the Heron Bridge collapsed. Senior representatives of M. M. Dillon Limited, supervising engineers, and Gaffney Construction, general contractor, were present.

Mayor Reid announced at the outset that reporters would not be allowed to question them. "We cannot discuss causes and responsibilities at this time." said the Mayor, "but board of control probably will be considering a recommendation from the planning and works department later today." The Mayor also declined to give any details of the investigation now being carried out by various agencies.

J. H. Kearney, Ottawa manager of the Dillon firm, said, "We have no idea what initiated the collapse," but he did give a factual account of how the bridge went down. This was how he described it:

"There are two layers of concrete on the bridge deck. The lower layer was poured about a month ago. Workers yesterday started pouring the top layer of the 217 by 50-foot bridge segment. They began in the center and were proceeding toward the east end. The deck is supported by two main piers which leave 34 feet of the deck projecting beyond the piers at each end. As workmen neared the finish of the pour on the east overhang, the single layer of concrete overhanging the west end "somersaulted" into the air and pancaked on the rest of the bridge. It collapsed within seconds." (Exhibits IV to IX).

"Wooden Shoring to Blame"

August 12, 1966
from Citizen

Roland Loreton said this morning that the falsework shoring was too weak to support the pouring of the concrete. Mr. Loretan is senior resident engineer at the site. He had been junior to Mr. R. Baird, Chief Engineer who was killed along with the other men in the collapse of the span. In an interview, Mr. Loretan discounts speculation that improperly cured concrete, unusually himid weather, or rushing the job caused the tragedy. "Certainly they may have been contributing factors," the engineer said, "but it is also part of their job to support the concrete until it is dry. The steel reinforcements that run through it are tightened or stretched. The shoring should be strong enough to support anything." He said, "You should even be able to pour gravel in there."

The chief engineer had been standing on one section of the span and was smashed by the jack-knifing. "I had been standing there just two minutes before

it happened." Mr. Loretan said he was just getting back to the office shack when he heard the rumble. The falsework was designed and built by the contractors, O. J. Gaffney Limited, but it had to be approved by Mr. Loretan's firm.

It was Mr. Loretan who tested the ground under the span to determine its endurance for the falsework. "The trouble could have been right there," he said. "It would be highly impractical to test the entire piece of ground under the span. It took three days to test a piece of the square. The whole thing would have taken three years. You never know when there might have been a stump under there that could have affected the testing. Something that would give way if a big enough load was put on it."

"Next to the death span stands its mate ready for concrete pouring as the up river one was earlier in the week. You would think the logical thing to do would be to strengthen the falsework under that one right away, but you can't tell, perhaps the ground under that span can hold the load." Mr. Loretan stressed his firm's willingness to help with the investigation for the cause of the collapse. "We are as anxious as anyone to find out who is at fault even if it turns out to be us, which we certainly hope isn't the case."

from Citizen

Bridge Aftermath

Mass province-wide construction walkouts have been threatened in the wake of Wednesday's Heron Bridge tragedy as angry union leaders campaign to have the province take over responsibility for safety inspection "We have said for a long time that these bridge jobs were perilous if the safety rules were not strictly enforced," said Jerry Galliger, Secretary-Treasurer of the 3,000 member Toronto Labour Union. "Now is the time to check the rules while the tragedy is fresh in everyone's mind."

"The problem is the inspection system. There is no point in having safety acts if there is no government inspectors to enforce them," he said. "Three men have been killed in one Toronto print shop. Our men are being killed as a result of mass production. . . . I am no crusader," Mr. Galliger said, "but I am propelled into action by the shock of the statistics and I do not plan to sacrifice any more men. The weakness of the act today is that there are no competent inspectors to enforce it. Many municipalities have good inspectors, but as soon as they bear down on contractors, pressure is put on by local politicians friendly with contractors."

August 13, 1966
from Citizen

No Coverup

The office of Crown Attorney John Cassells disclosed that a firm of consulting engineers H. G. Acres Co. Limited of Toronto has been retained to make a full investigation into the cause of the collapse.

There will be no coverup or soft pedaling of the facts in the probe into Wednesday's disastrous bridge collapse, Ontario supervising coroner, Dr. H. B. Cotnam, made this comment at a press conference last Friday.

"When this phase of the probe has been concluded the inquest will be held. All evidence will be presented under oath," Dr. Cotnam said. Under the

Court's Act he has full authority to proceed as he sees fit and not permit anyone, including the City of Ottawa, to interfere or direct the official investigation. "City engineering experts and those contractors wishing to engage will certainly be heard at the inquest if they have any facts to offer of value."

The Toronto firm has been given complete authority to proceed with the technical end of the probe. He added that no one save the official investigators will be allowed on or near the bridge site until Monday at the earliest.

The Ontario Labour Department has issued a Stop Work Order on all work at the site. Dr. Cotnam said he expects it will take from four to six weeks to complete the technical investigation and the inquest date cannot be set until then.

Dr. Cotnam said that at the inquest he will instruct counsel for the interested parties to examine any witness they may wish to question. This procedure is a rare one especially at inquests. The supervising coroner said he feels that it is in order under the circumstances. "It is a matter of the coroner's discretion," Dr. Cotnam said. "This was a very terrible catastrophe and we will treat it just as we would any other case involving negligence. We will let the chips fall where they may."

Dr. Cotnam was asked whether he would comment on a statement given to the press Friday where Mr. Loretan, Assistant Engineer on the bridge site, said, "He believed that improper shoring was the blame for the collapse." "I certainly have no comment at all to make on such a statement," Dr. Cotnam replied, "This is an area to be explored at the inquest."

from Journal

The supervising coroner broke up his holiday Friday to come to the city for a two and a half hour meeting with Crown Attorney John Cassells and representatives of both the city and provincial labor department. He said later that all agreed on his plan for an inquest which would be the only official inquiry into the accident.

Meantime, James McNair, chief engineer in the construction safety branch of the Ontario Labor Department, said his investigation is progressing and said copies of his findings will be available to Dr. Cotnam and the city and provincial authorities. But, he like the coroner, forecast the major assessment of the accident will be made by the engineers retained for the inquest. The practice of engaging experts to advise coroners in Ontario has resulted from changes in provinical legislation and the cost in paid by the city as part of the witness fees for the inquest.

from Citizen

There could be several reasons for the failure in addition to faulty falsework. Two other possibilities were: overloading of the falsework by weight of the concrete being poured above or failure in the work footing below. The task of determining the exact cause would rest with the inquest now being planned by Ontario supervising coroner, Dr. H. B. Cotnam.

Just who was responsible for safety inspection at the site has been in some doubt since the disaster. Mr. Ayres today gave this explanation. "The designers of the bridge, M. M. Dillon Ltd. were responsible for supervision during the construction, but the site was also visited 'periodically' by city safety inspectors. These inspectors, however, were mainly interested in safe construction methods and were not trained to assess the engineering complexities of the bridge design.

August 17, 1966
from Citizen

Editorial: Who is to Blame When Bridges Fall?

Where does the responsibility of construction safety lie. The Heron Bridge disaster and construction fatalities elsewhere give urgency to the question. Safety experts provide guide lines which reduce hazard but they acknowledge that human error and uncertain factors in design or combinations of wind, storm and temperature may make gibberish of their calculations. The safety guide lines are widely honored in Canada: The National Building Code and the Canadian Standards Association list materials and their strength. The code hastened by General A. G. L. McNaughton, when he was head of the National Research Council, ended the chaos which existed in building regulations when every municipality had its own set.

The Code, kept up to date by NRC, is imposed on no one. It is labeled "Advisory." Yet it has been incorporated into their building regulations by 93% of Canadian cities in whole or in part. Ottawa, for example, has adopted the major sections of the code with the variations that some provisions have been made stiffer to meet what city authorities think necessary here.

The code sets minimum regulations for safety. NRC says that its essential purpose is a promotion of public safety through the use of desirable building standards throughout Canada. When the code is observed, a building in Nova Scotia and British Columbia will have comparable quality. The code plus CSA data on what steel, concrete and other materials may be expected to bear represents the foundations of building construction safety. The code was prepared to cover building only, but the principles are known to and respected by bridge builders.

Buildings may be similar but no bridges are identical twins. The National Safety Guides being advisory are not compulsory. The provinces and municipalities are left to enforce construction regulations they consider necessary. In addition to provincial laws and bylaws, there is a kind of cooperation and common intent for safety which works fairly well but is a system which has strength and weaknesses.

So far as the law is concerned, Ontario authorized municipalities to pass building bylaws and also has its own inspectors under the construction safety act. Ottawa in 1960 issued 55 million 700 thousand dollars in building permits and had seven building inspectors. In 1965, permits were of a value of 107 million 240 thousand dollars and there were 14 inspectors including 3 safety inspectors. The latter from time to time checked on the progress of the Heron Road Bridge construction.

What is plain is that the city and provincial inspectors no matter how numerous, could not check every detail of construction. There has to be reliance on the actual builders and private company supervisors. A responsible contractor knows that his business can be swept away if he does shoddy or reckless work. He insists on good men checking the work of others. Not all contractors are responsible. There are "fly-by-nights." The Canadian Construction Association with more than 1,500 contractor members lament that anybody can become a contractor by announcing himself as such. They look forward to the day when every contractor will have to prove experience, financial responsibility and ability to produce staff and equipment before being able to claim his "title."

The reckless contractor makes inspection even more essential, and when he employs unskilled men the hazard is increased. Carpenters used to serve an apprenticeship of 4 years but now a man can buy a hammer and an apron and get a job. If there is no skilled foreman to keep him under close supervision, there is danger.

Beyond the contractor is the consulting engineer, the chief custodian of safety on any project. His job is to see that the work is done according to plan and safe. He may not have the last word. He may tell the contractor that 2 inch by 4 inch boards are not enough at one point. The contractor may consider it safe enough, pocket the letter of protest the engineer sends him and go ahead. If that structure fails, the contractor is in trouble and the engineer has clean hands. Safety chiefly depends on the cooperation of engineers, contractors, foremen and workmen, working responsibly together.

"You can't legislate safety," an Ottawa expert said. This is true as a generality, but codes and standards and accumulated experience of the industry does prove that there is a pattern of errors which can be avoided.

LIST OF EXHIBITS (A)

from Report	Exhibit A-1: Location of the Heron Road Bridge Site
from Report	Exhibit A-2: General Arrangement of Heron Road Bridge
from U.P.I.	Exhibit A-3: Heron Road Bridge Before the Collapse
from D-W Photos	Exhibits A-4 through 9: Views of the Heron Road Bridge After the Collapse

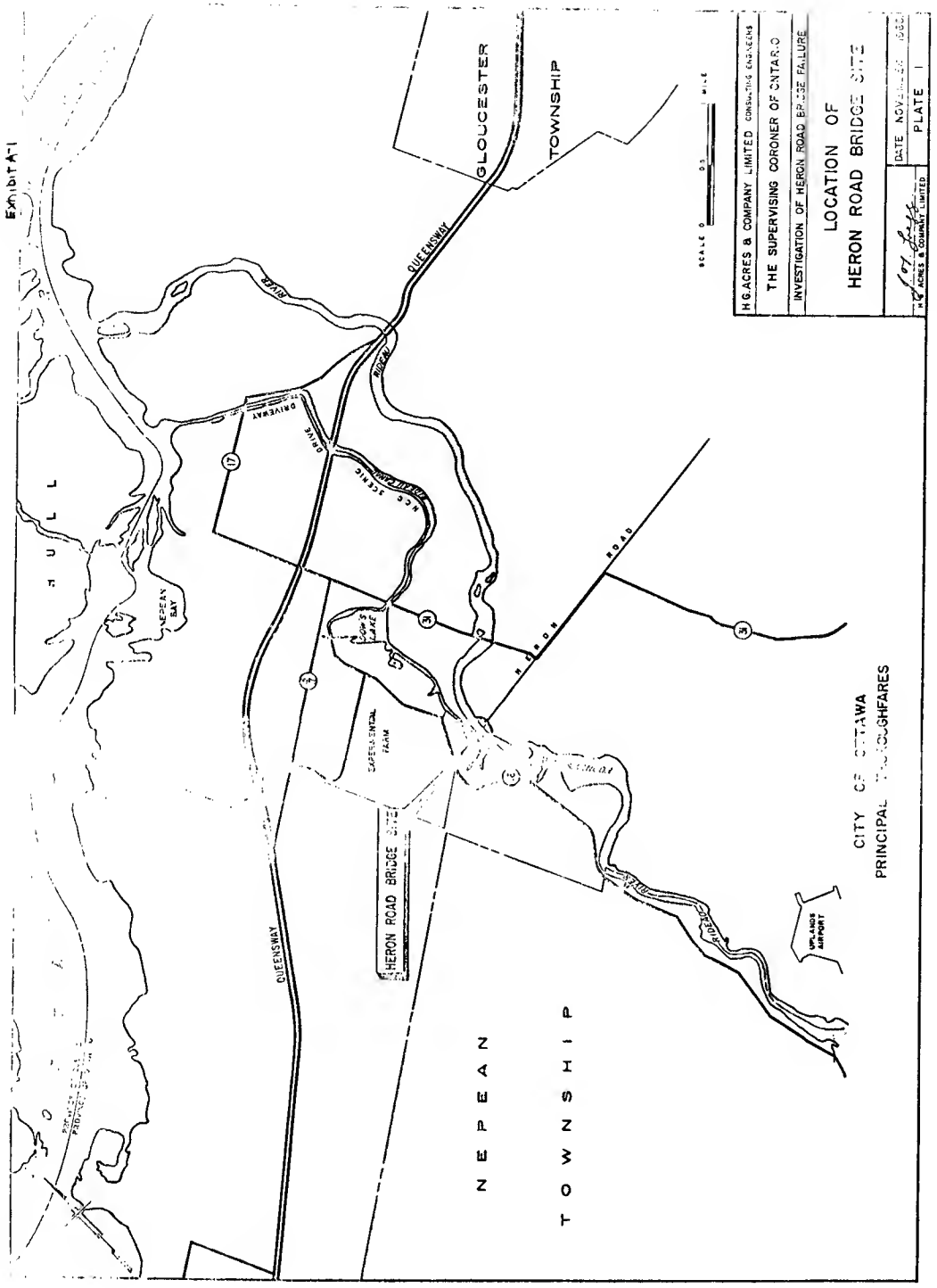


Exhibit A-1. Location of the Heron Road Bridge Site

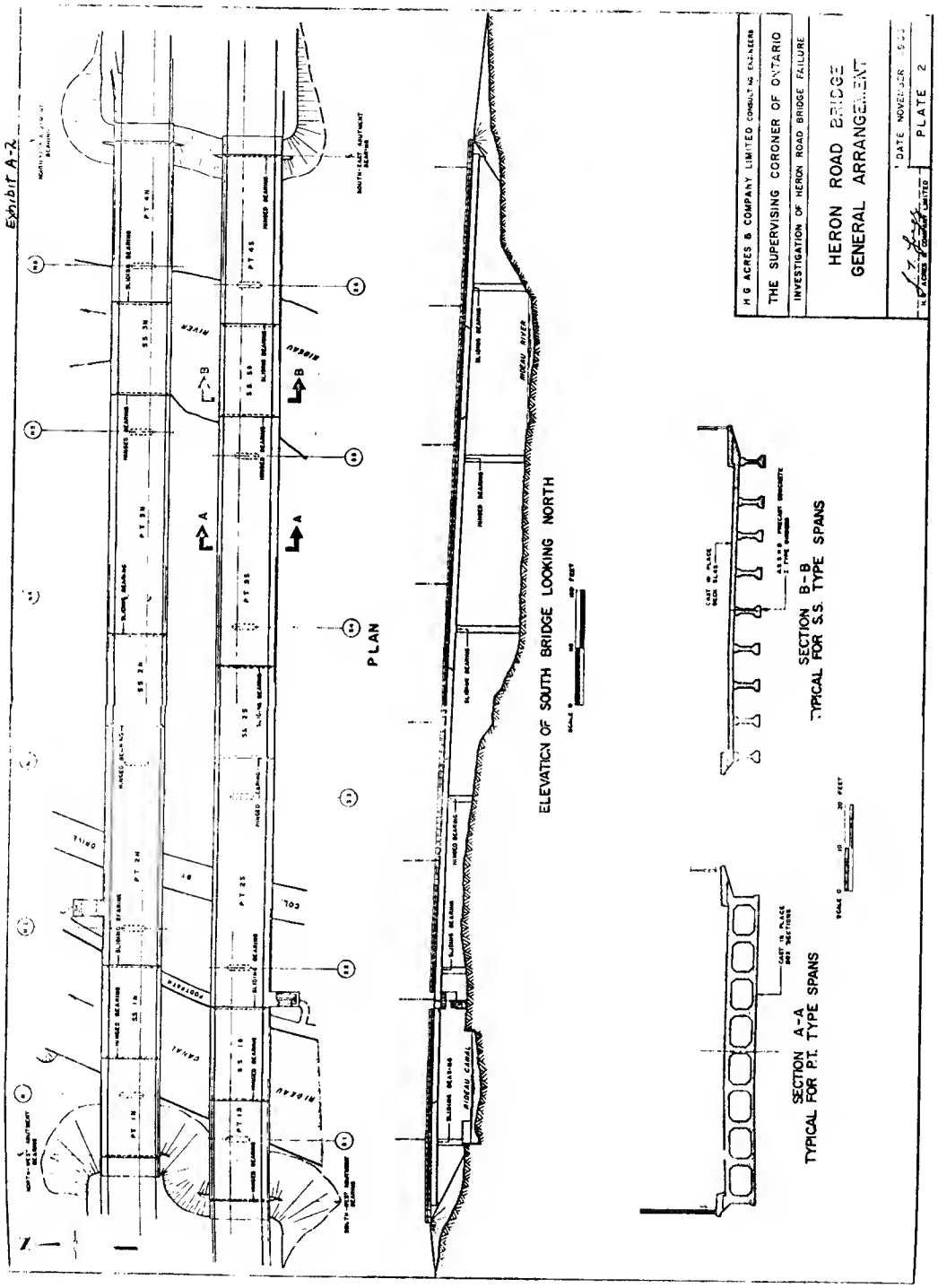


Exhibit A-2. General Arrangement of the Heron Road Bridge

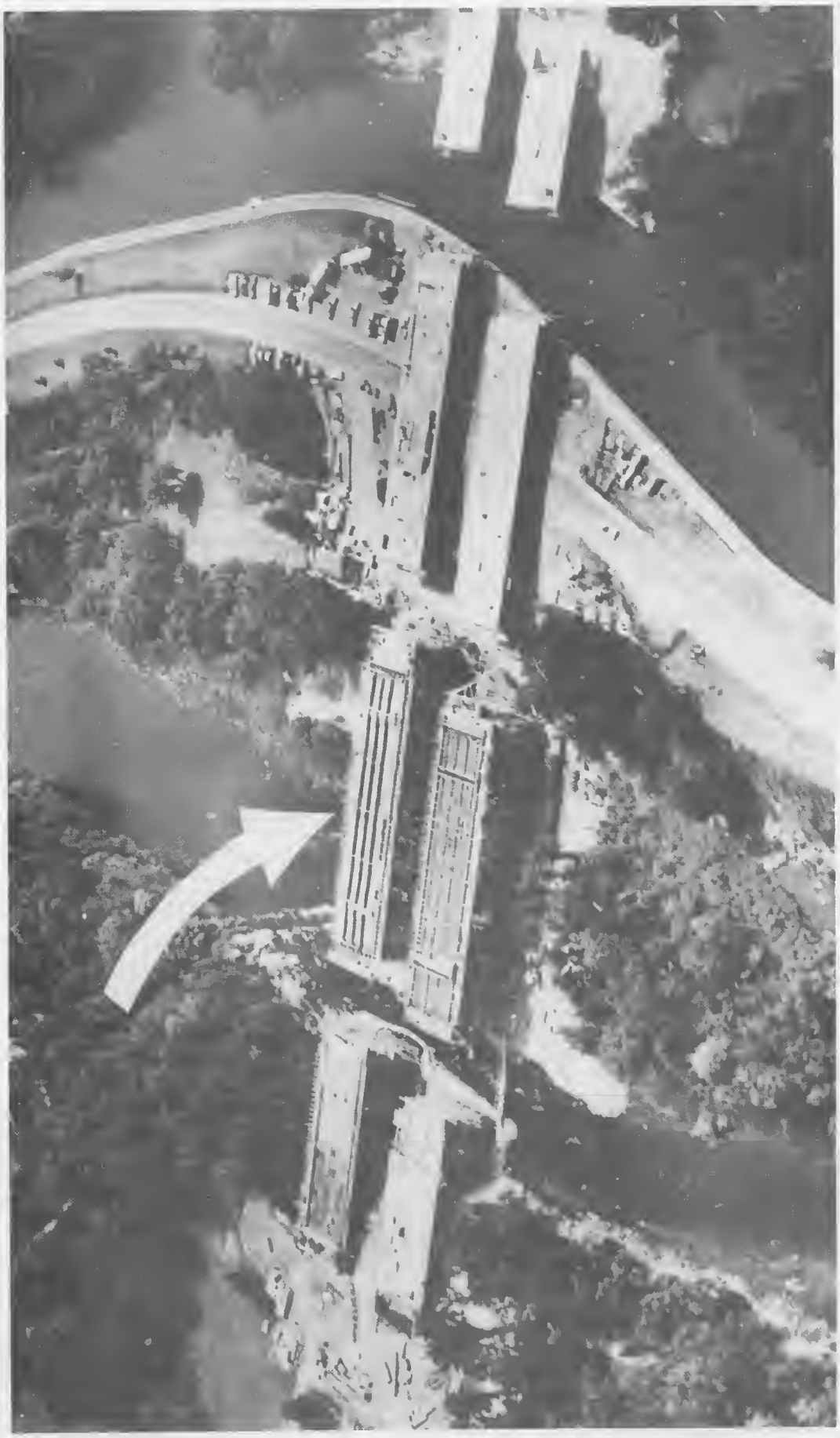


Exhibit A-3. Heron Road Bridge before the Collapse (from U.P.I.)

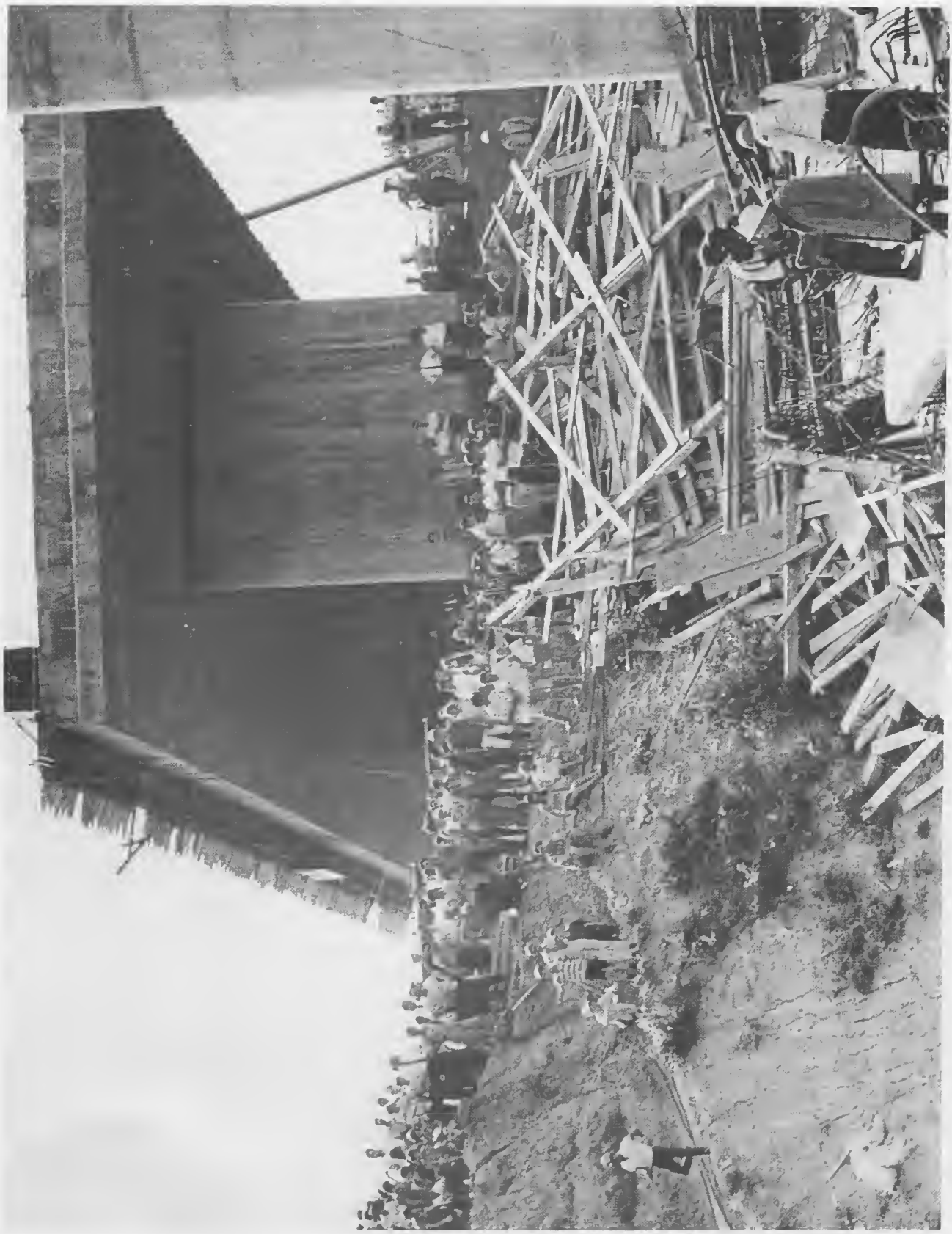


Exhibit A-4. Heron Road Bridge after the Collapse (from D-W Photos)

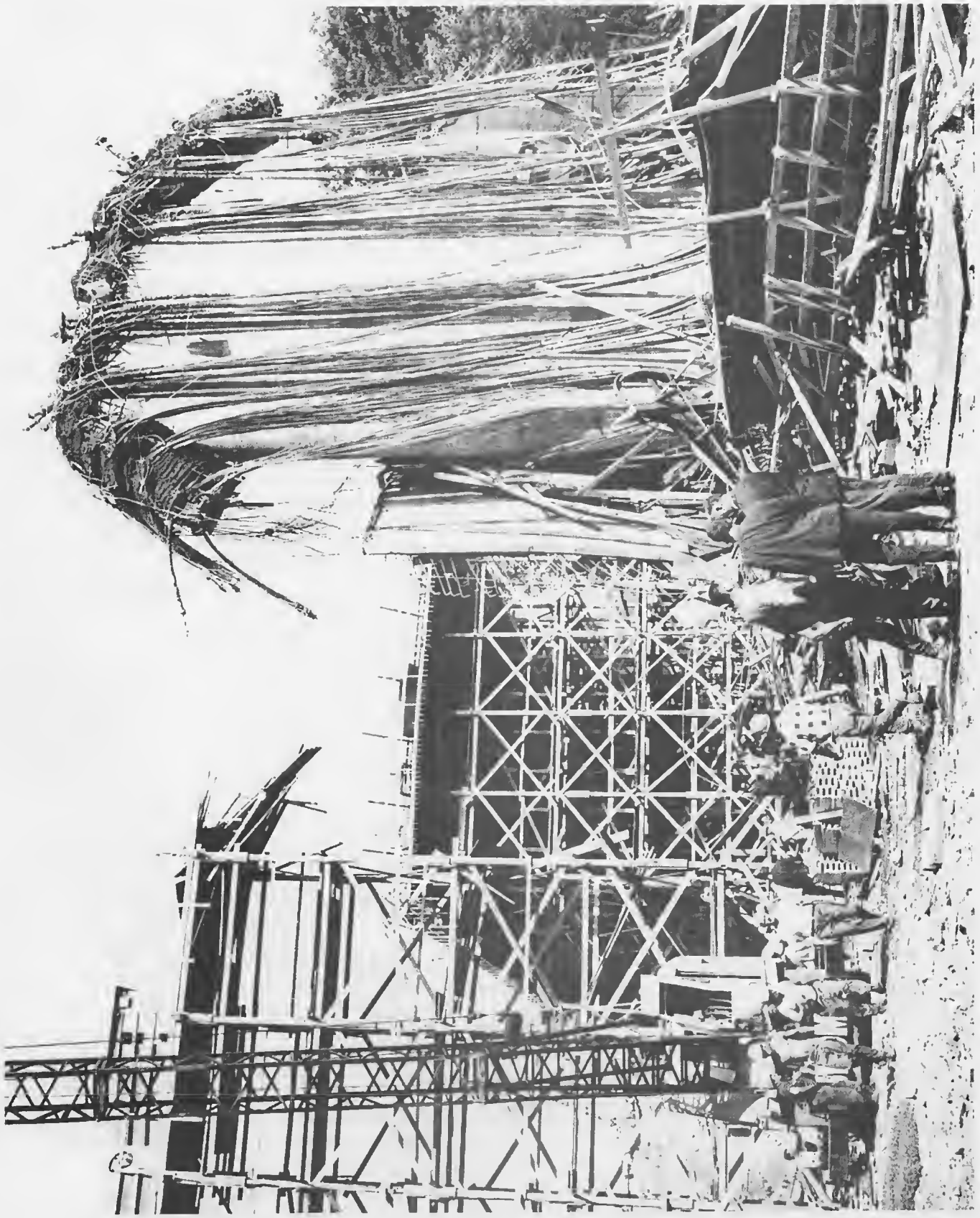


Exhibit A-5. Heron Road Bridge after the Collapse (from D-W Photos)

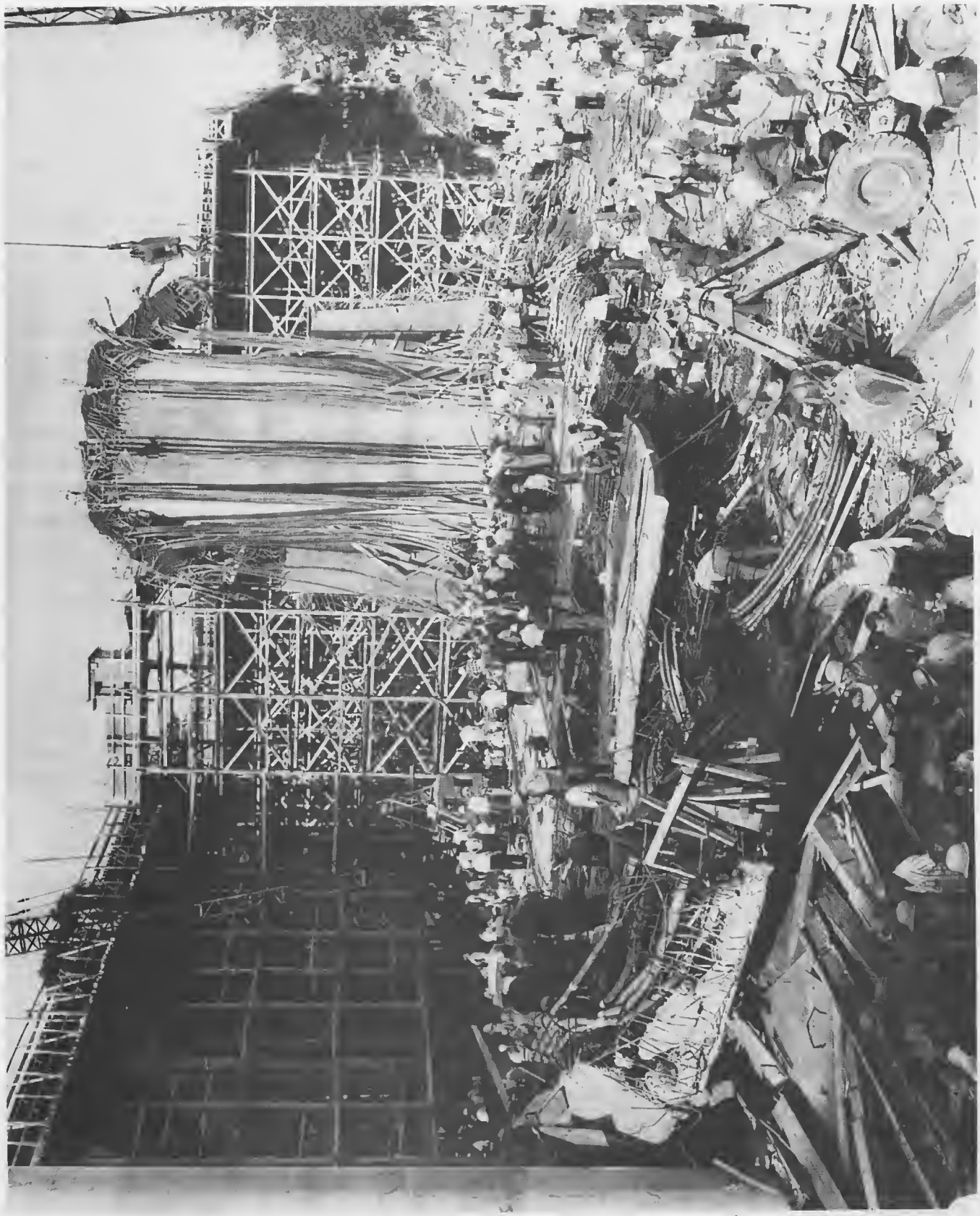


Exhibit A-6. Heron Road Bridge after the Collapse (from D-W Photos)

Exhibit A-7. Heron Road Bridge after the Collapse (from D-W Photos)

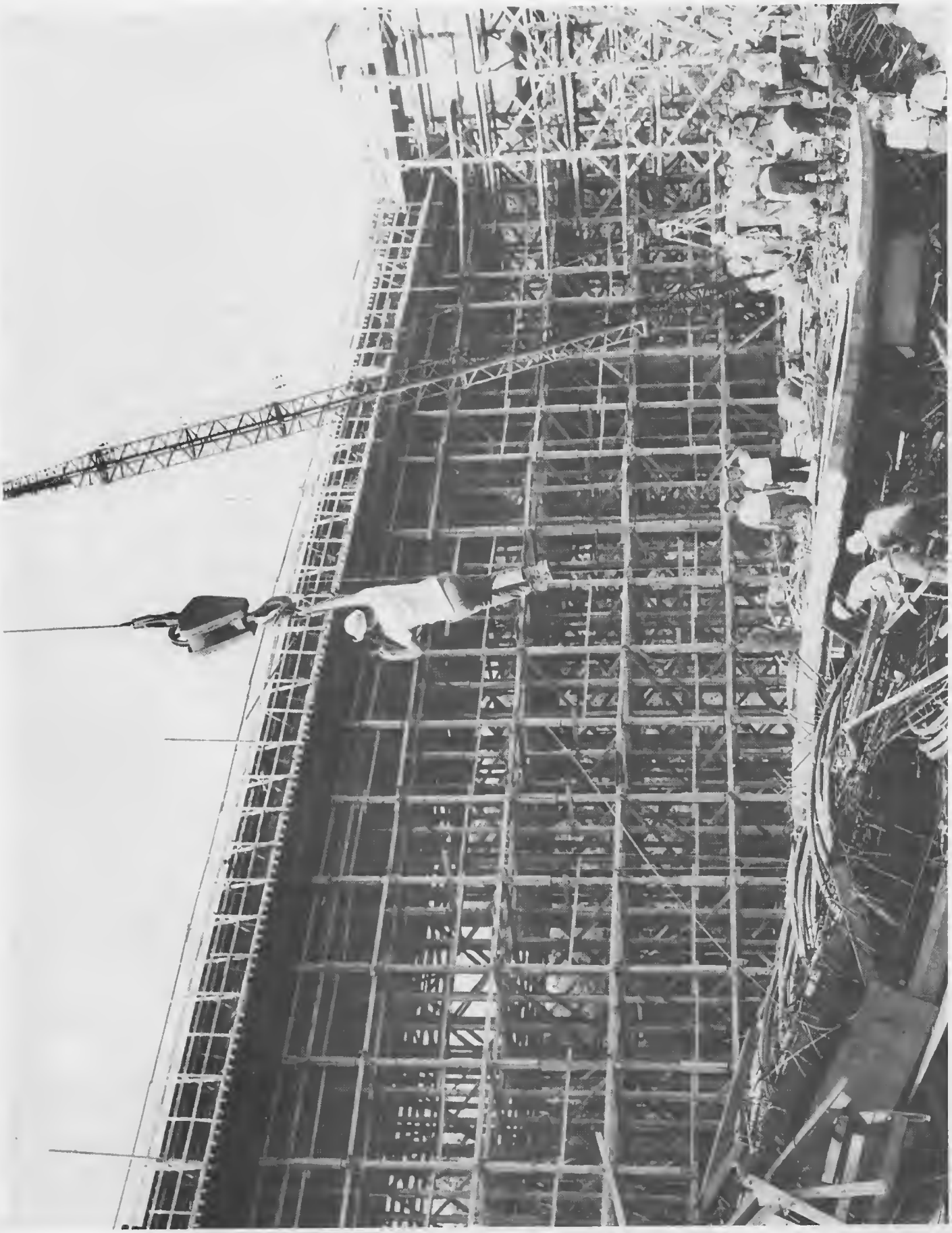


Exhibit A-8. Heron Road Bridge after the Collapse (from D-W Photos)

Exhibit A-9. Heron Road Bridge after the Collapse (from D-W Photos)

HERON ROAD BRIDGE CASE

Think Questions

PART A

1. Why was the bridge superstructure designed as a determinate structure?
2. What is falsework?
3. From the photographs and drawings can you describe the falsework?
4. What probable causes of falsework failure were advanced in the case?
5. What do you think was the reason for the failure of the falsework?
6. Who do you think is responsible for the failure? Financially? Morally?
7. Will a public inquiry as proposed harm or help the engineering profession?

References

All the material in the case is quoted directly from published sources referenced below.

(1) *The Ottawa Citizen, published by Southam Press Ltd. at 13 Sparks Street, Ottawa 4, Ontario. (Citizen)*

(2) *The Ottawa Journal, published by The Journal Publishing Co. of Ottawa Ltd. 237 Queen Street-234 Sparks Street, Ottawa, Ontario. (Report)*

(3) *"Report on the Heron Road Bridge Failure," H. G. Acres & Co. Ltd. for the Supervising Coroner of Ontario, (Report)*

(4) *The Professional Engineer and Engineering Digest, 46 St. Claire Avenue, E., Toronto 7, Ontario. (Digest)*

(5) *Association of Professional Engineers of Ontario, Toronto, Ontario. (A. P. E. O.)*

(6) *United Press International Newspictures, 133 Queen Street, Ottawa 4, Ontario, (U.P.I.)*

(7) *Dominion-Wide Photographs, 226 Sparks Street, Ottawa 4, Ontario. (D-W Photos)*

ECL 133B

HERON ROAD BRIDGE (B)

Part B of this case is taken from "Report on the Heron Road Bridge Failure," H. G. Acres & Company Limited, for the Supervising Coroner of Ontario. (Reference 3). The table of contents, the introduction, the terms of reference, the conclusions and recommendations are given in their entirety. The remainder is an abstract of the more pertinent parts of the report. The appendix is an excerpt from Department of Highways, Ontario (DHO), Form No. 9, Revised August, 1963, Clause 9.04.13 "Formwork and Falsework," the common standard for all bridge construction in Ontario.

Please Reply to: The Arcade Building
74 Victoria Street
Toronto, Canada
Phone 362-5961

November 18, 1966
1493

Dr. H. B. Cotnam
Supervising Coroner of Ontario
c/o Attorney General's Department
897 Bay Street
Toronto, Ontario

Dear Sir:

Investigation of Collapse of
Heron Road Bridge, Ottawa

We take pleasure in submitting our report on the causes leading to the collapse of the falsework on a portion of the Heron Road Bridge in Ottawa on August 10, 1966.

Our conclusions and recommendations are summarized in Section 2 of the report. We have concluded that the prime cause of failure was an error in the design of the falsework, resulting in a lack of adequate bracing.

We thank you for this opportunity to assist you and trust that the report will meet your requirements. Please call on us if any questions arise or if any clarifications are needed.

The assistance and co-operation provided by the staffs of the Attorney General's Department, the Ontario Provincial Police, and the City of Ottawa Police Department throughout our investigation are gratefully acknowledged.

Yours very truly,

J. T. Gregg
Executive Engineer

H. G. ACRES & COMPANY LIMITED CONSULTING ENGINEERS
1259 DORCHESTER ROAD NIAGARA FALLS CANADA TELEPHONE 354-3831

H. G. ACRES & CO.

Report on the Heron Road Bridge Failure

TABLE OF CONTENTS

* Given in its entirety
** Abstracted

1 – INTRODUCTION AND TERMS OF REFERENCE

Following the collapse of a portion of the Heron Road Bridge in Ottawa, Ontario, on August 10, 1966, while under construction, the Supervising Coroner of the Province of Ontario retained H. G. Acres & Company Limited, Consulting Engineers, to assist him in the investigation of the cause or causes of the collapse. The accident apparently led to the death and injury of workmen. The terms of reference given to the Consulting Engineers by the Supervising Coroner, Dr. H. B. Cotnam, in consultation with the Department of the Attorney General of the Province of Ontario were as follows. H. G. Acres & Company Limited is to investigate and report on:

(a) The terms and conditions upon which consulting engineering and testing services were obtained by the City of Ottawa for the planning, design and construction of the bridge and whether the same were adequate and reasonable for the purpose.

(b) The terms and conditions, design, specifications and drawings in accorance with which tenders for the construction of the bridge were invited by the City of Ottawa and whether the same were adequate and reasonable for the purpose.

(c) All tenders and contracts received or made for work, supply of materials and services, the action taken to investigate same, the circumstances surrounding the acceptance of said tenders or the making of said contracts, and whether these were reasonable and justified in the circumstances.

(d) The design adopted for the bridge and temporary works, and whether the same were adequate and suitable.

(e) The materials, methods and workmanship used in the construction of the bridge and temporary works, the standard and suitability thereof, and whether they were in accordance with the contract specifications.

(f) The nature, extent and standard of all supervision and inspection at all levels over the construction and erection of the bridge, and whether the same were reasonable and adequate.

(g) Whether any act or omission directly or indirectly caused or contributed to the collapse.

(h) Whether the designs and specifications and the construction of the bridge in accordance therewith were reasonable having regard to the known state of engineering and scientific knowledge and experience subsisting at the time of construction.

In the execution of its duties, H. G. Acres & Company Limited was directed to work in close association with Inspector G. A. Duguid of the Attorney General's Department, who was appointed Special Investigator for the Crown and assumed control of the wreckage on behalf of the Supervising Coroner.

2 – CONCLUSIONS AND RECOMMENDATIONS

2.1 The basic cause of the collapse of the structure was a buckling failure of the falsework which was insufficiently braced in the longitudinal direction. The occurrence of the failure at that particular time may have been influenced by one or a combination of the following secondary factors:

differential settlement of footings;

temporary overloading of posts of transverse bent 23;

a possible material weakness of some highly loaded members of the falsework;

However, had the falsework been sufficiently braced, these secondary factors normally would not have caused failure of the structure.

2.2 The falsework was inadequately braced even to support the imposed loads at the time of pouring the bottom slab of the bridge deck, that is one month prior to the collapse. The structure withstood these loads successfully only on account of its inherent rigidity due to friction in the joints of the structure and due to the flexural rigidity of the transverse bents, factors not normally counted on in design.

2.3 The terms and conditions upon which consultant engineering services were obtained by the City of Ottawa from M. M. Dillon & Company Limited for the planning, design and construction supervision of the Heron Road Bridge Project, were in accordance with standard Canadian practice. They were adequate and reasonable for the intended purpose.

2.4 The design of the bridge project, the specifications and drawings–in accordance with which tenders for the construction of the bridge were invited by the City of Ottawa–were in accordance with standard Canadian practice. They were adequate and reasonable for the intended purpose.

2.5 The tender submitted by Beaver Construction Limited for the construction of the foundations of the bridge, Contract No. 64-77, was reasonable, and its acceptance by the City of Ottawa justified under the circumstances.

2.6 The tender submitted by O. J. Gaffney Limited for the construction of the bridge structure, Contract No. 64-78, was reasonable, and its acceptance by the City of Ottawa and approval of the appointment by the Department of Highways of Ontario justified under the circumstances.

2.7 The design adopted for the bridge project was in conformity with recent developments in bridge engineering. It was adequate and suitable, and complied with the applicable codes and specifications in current use for such projects.

2.8 The design adopted for the temporary falseworks was not adequate and not suitable for the project, since it was erroneously based on the assumption that the permanent piers would give adequate longitudinal support to all portions of the falsework structure.

2.9 The materials, methods and workmanship used in the construction of the bridge were in conformity with standard Canadian practice. They were suitable for the project, and were in accordance with the contract specifications.

2.10 The methods and workmanship used in the construction of the temporary falsework were generally suitable, but the timber used for the posts of the structure were not of sufficient quality for the intended purpose.

2.11 The nature, extent and standard of supervision and inspection of the construction of the permanent bridge were reasonable and adequate.

2.12 The nature, extent and standard of supervision and inspection of the construction of the temporary falsework was inadequate.

2.13 The act of removing the longitudinal, diagonal bracing from the construction drawings for the falsework for span PT3S, O. J. Gaffney Limited drawings Nos. G-1886-14 and 16, which led to the preparation of the revised drawings Nos. G1886-14A and 16A, indirectly caused the collapse of the structure.

2.14 It is recommended that the Department of Highways Form No. 9, Clause 9.40.13 (Formwork and Falsework) be revised to provide for:

a) Mandatory design live loads including a horizontal live load of 2 per cent of all dead and live loads acting at the level of the falsework at which the vertical loads are applied.

(b) The list of species of lumber specified therein be expanded to include eastern red pine and eastern white pine including the appropriate stresses as permitted by the applicable CSA specifications (presently under review).

(c) A paragraph drawing attention to the grading requirements of CSA specifications and rules governing use of lumber not stress graded.

(d) A requirement that approved design and construction drawings for falsework carry the stamp of a Registered Professional Engineer (Civil).

2.15 It is recommended that a "Falsework and Formwork" section be included in the National Building Code embodying the contents of the Department of Highways, Ontario (DHO) Form No. 9 revised as suggested above.

5.1 – **Design**

(a) **Substructure**

The piers and abutments of the Heron Road Bridge are of reinforced concrete construction. All the foundations are designed in accordance with the requirements of the appropriate design codes and are capable in our opinion of sustaining the anticipated loads.

On account of the type of falsework structure used, the permanent piers were called upon to resist some horizontal loads during construction. There is nothing on record to show that such a design check was carried out by either party when considering the falsework stability.

(b) Superstructure

The bridge has been checked for stability in the longitudinal and transverse directions and found to be satisfactory, including the application of Zone 2 earthquake forces as specified by the National Building Code of Canada.

The critical deck elements have been assessed for structural adequacy under the various combinations of loading specified by the A.A.S.H.O. "Specification for Bridges."

A design check of a typical interior and exterior beam for both the suspended composite beams and the post-tensioned cast-in-place elements, including transverse diaphragms and bearing assemblies, revealed that in all cases the design meets the requirements of the applicable design codes.

During the design period M. M. Dillon and Company Limited worked in cooperation with the DHO Bridge Office who took an active part in formulating the design and finally approving the plans for construction. The Department had reservations regarding the support arrangements for the suspended spans, but agreed to this detail since they have used a similar arrangement on some of their own recent bridges and there have been no reports of defects after a period of several years in service.

The drawings for the falsework do not call for a specific grade of lumber for the falsework with the exception of hardwood capping beams and wedges. The calculations prepared by the contractor are based

on the requirements of DHO Form No. 9 "Specifications for Structures." This specification did not form part of the contract documents for this contract but since it is produced by the DHO it is widely accepted as a guide to design of bridge falsework by the construction industry. DHO Form No. 9 mentions only two species of lumber for use in falsework, namely B. C. fir and eastern spruce, and the physical properties of these are given to CSA Specifications 043 "Structural Timber."

The contractor's design calcualtions approved by the supervising consultants assume the use of eastern spruce, stress graded to CSA requirements. Eastern spruce was supplied for the 2 by 6 bracing material to "Construction" grade in accordance with the Standard Grading Rules of the Eastern Spruce Grading Committee. Six-inch by six-inch eastern spruce or red pine was ordered from the supplier for the posts and supplied to a "merchantable" grade. None of the material supplied was stress graded to CSA requirements. This is not unusual as most yard lumber is either not graded at all or, if it is, it is graded in accordance with CSA or Eastern Spruce Grading Committee requirements. Before "merchantable" or yard lumber is used in a permanent structure, it should be graded piece by piece to ensure compliance with CSA 043 requirements. This procedure is not normally required for temporary construction such as falsework.

Material of an inferior quality to that assumed in design was used for the construction of the falsework. This possibly hastened the collapse but, regardless of the grading of the lumber, the falsework would have failed anyway.

During erection of the falsework, the construction was inspected by a Safety Inspector in the employ of the City of Ottawa and by a representative of the Department of Labor. Their visits were to ensure that the requirements of the Construction Safety Act were being observed. Several instructions were given in writing to the contractor regarding safety rails, working platforms and the like but there is no comment regarding the structural adequacy of the falsework. Apparently the lack of diagonal bracing in both directions, a requirement of the Act, was discussed by the inspectors and a junior representative of the contractor.

We must assume that the structure was inspected and approved for compliance with the Construction Safety Act by the City of Ottawa safety inspector, acting on behalf of the Department of Labour.

We have taken samples of materials used to construct the bridge and tests verify that these have been supplied in accordance with the requirements of the specifications.

6 – Falsework

6.1 – Introduction

Generally, the falsework for span PT3S was similar to the falsework for span PT3N.

6.2 – General Description of Falsework before Collapse

(a) The Falsework Structure

The falsework for span PT3S was a nailed and bolted timber structure resting on concrete footings and supporting steel beams at the top, which in turn supported the formwork for the permanent concrete bridge. The timber structure consisted essentially of vertical posts and longitudinal and transverse bracing, designed to sustain the vertical and horizontal loads imposed on the structure during the construction of the permanent works.

All transverse bents were connected to one another by longitudinal horizontal bracing and connected to the previously completed permanent piers by blocking and form ties.

A general arrangement of the falsework is shown on Plate 5. Particular attention is drawn to the following:

(i) Lack of longitudinal bracing
(ii) Method of tying falsework to permanent piers
(iii) Attachment of transverse bracing to posts

(b) **The Structural Characteristics of the Falsework**

All vertical loads, except those carried by the permanent piers, were transferred to the vertical posts, and then led through the concrete footings into the ground.

Horizontal loads in the transverse direction were resisted by the truss action of the transverse bents. The bottom slab of the bridge, which existed at the time of collapse, assisted in resisting horizontal loads by providing a stiff horizontal diaphragm between the permanent piers.

Horizontal loads acting on the bents in the longitudinal direction were resisted by the horizontal longitudinal bracing which was partially tied to the permanent bridge piers.

6.3 – **Loading**

(a) **Loading of the Falsework at the Time of Collapse**

Dead load was produced by the weight of the falsework and formwork and by the weight of the concrete slab poured as part of the permanent bridge structure about one month prior to the collapse. This slab was about 44 feet wide and 233 feet long, varying in thickness between 7.5 and 10 inches.

Live load was produced by the weight of the fresh and not yet hardened concrete poured on the day of the collapse, and in addition, by men and construction equipment.

There was no appreciable wind and no earthquake activity in the vicinity of the Heron Road Bridge at the time of collapse. Therefore, the following axial loads which were calculated using the details on O. J. Gaffney Limited's drawing for the falsework and the details of M. M. Dillon's drawings for the permanent bridge were applicable to the posts at this time.

Average load	–	21,000 lb.
Maximum load	–	27,000 lb.
Minimum load	–	5,000 lb.

(b) **Effect of Sequence of Loading**

The falsework structure for span PT3S, as it existed at the time of collapse, could be considered an articulated structure, except for the steel beams located just underneath the bridge formwork, which distributed the imposed loads via the hardwood capping beams onto the transverse bents. These steel beams were continuous beams over three spans with the particular characteristic that the forces transmitted to the hardwood capping beams were greater for the partially loaded beams than for the fully loaded beams. In this particular instance the transmitted forces could have reached an intermediate value about ten per cent greater than the corresponding forces for the fully loaded beams. On an articulated structure the maximum forces would have been about twenty per cent less than above mentioned maximum intermediate value.

On the day of the disaster, pouring of concrete had commenced at about the center of span PT3S and had progressed at more or less uniform rate across the width of the bridge to a line about 20 feet east from pier S5, when failure occurred. At this stage the steel beams spanning between bents 22 and 25 had been loaded such as to just about produce the above mentioned maximum intermediate force on the posts of bent 23.

6.4 – Structural Strength of the Falsework Structure

(a) Structural Composition of Falsework

The plywood formwork for the final bridge structure was supported on transverse wooden joists which were resting on steel beams place longitudinally. Transversally arranged hardwood capping beams topped the transverse structural bents and supported the steel beams.

(b) Steel Beams

Each steel beam was made up of two 10-inch rolled sections, fastened together by welding. The beams were continuous over four bents and rested on transverse hardwood capping beams. The capacity of the steel beams was adequate to safely support the imposed loads.

(c) Hardwood Caps

A 6-inch by 10-inch capping beam was used at the end supports of the steel beams, while a 6-inch by 6-inch capping beam was used at interior supports. These caps had adequate capacity to safely carry the imposed loads.

(d) Timber Posts

The vertical posts, of the falsework structure were 6-inch by 6-inch timbers of assorted species, but generally red or white pine. The timber was not structurally graded before the collapse. There was an unusually high percentage of weak pieces in the timbers. The compression modulus of elasticity of the specimens tested was lower, on the average, than the national average; however, the low values for the specimens was in line with the low values obtained from a national sampling.

Each post was spliced three times throughout its height. The splice details conformed to standard practice with the exception of the location of the splice, which is normally made at or close to the point of lateral support.

Although the strength and quality of the timber were too low to provide for an adequte factor of safety for maximum loading, the timber posts would not have failed if adequate bracing had been provided at all panel points.

(e) Transverse Bracing

In the transverse direction, horizontal 2 by 6 dressed timbers were combined with 2 by 6 diagonals to provide lateral bracing of the posts at 10-foot 8-inch centers. The horizontal bracing was nailed to each post, whereas the diagonal bracing was bolted, but the bolting was carried out at the outside and center posts only. This bracing was to resist all horizontal loads and transverse buckling of the posts. Although this design did not provide for an adequate factor of safety under maximum design load, it was sufficient to stand up under the loading which existed up to and at the time of the collapse.

(f) Longitudinal Bracing

The longitudinal bracing consisted of horizontal 2 by 6 dressed timbers fastened to the vertical posts at the same places as the transverse bracing. It existed in all nine longitudinal lines of posts. Between the permanent piers, the three middle lines of longitudinal bracing were tied and/or blocked to the permanent piers. The similar lines of bracing under the east cantilever were tied and blocked to pier S5, but the bracing on the west cantilever was only blocked to the westerly pier.

The capability of the longitudinal bracing to resist horizontal loading was limited to that portion of the three middle lines, located between the piers. The longitudinal bracing of the remaining six

lines of posts and the middle three lines underneath the cantilevers was not capable of resisting the acting forces.

(g) **Footings**

The concrete footings were designed to lead all loads from the falsework structure into the ground.

(h) **Stability of Falsework Structure**

The falsework structure was fundamentally a system of vertical posts braced transversally and longitudinally. All connections were semi-hinged and would be considered hinges in an engineering analysis. This system is basically stable if sufficient and properly designed bracing is utilized. On this particular falsework structure, stability could have been achieved only if the transverse and longitudinal bracing were made capable of resisting all horizontal loads and of resisting the buckling of each and every column individually and collectively.

Sufficient strength to prevent collapse, but not sufficient to ensure a required factor of safety, was provided in the transverse direction by the system of horizontal and diagonal bracings.

In the longitudinal direction, sufficient strength existed only at the three middle lines of posts between piers S4 and S5, which were blocked and tied to the piers. In the remaining lines of posts horizontal longitudinal bracing was provided. This meant that all posts of each of these lines had to deform collectively, i.e. deform in the same direction at the same time. No bracing had been provided to effectively prevent such deformation.

In this case, longitudinal diagonal bracing arranged in horizontal or vertical planes would have been the appropriate counter-measure against longitudinal buckling collapse.

The basic concept of the design appears to have been a reliance on the permanent piers to provide supports for the falsework structure in the longitudinal direction. This concept was fallacious since only 1/3 of the posts were braced against the piers, while the remainer were hindered from deforming longitudinally only by the rather low flexural rigidity of the transverse bents, which in ordinary engineering design is not taken into account at all.

As a consequence, the buckling lengths of the posts of the outer six lines was the full height of the falsework structure and not the 10-foot 8-inch panel height assumed in the original design of the falsework. Under this condition, the posts were completely inadequate to support the loads applied to the structure at the time of collapse.

6.5 – **Nature of the Failure**

Engineering calculations revealed that the falsework structure was not even adequately braced to support the imposed loads at the time of pouring of the bottom slab of the bridge, i.e. about one month prior to the collapse. The reasons for which the falsework successfully withstood those loads can only be found in the inherent rigidity of the structure due to the existence of friction in the joints of the structure and due to the flexural rigidity of the transverse bents. Both these items are normally not taken into account when computing the stability of a structure.

After its hardening, the bottom slab of the bridge provided a stiff horizontal diaphragm between piers and increased the carrying capacity of the falsework. At this stage the posts in the six outer lines could be considered as having a buckling length equal to the height of the falsework for buckling in the longitudinal direction. The longitudinal and horizontal bracing would only ensure simultaneous buckling of all posts of one line thus mobilizing the deformation resistance of all posts even though only about one half

of the number of posts of the falsework were heavily loaded on the day of the collapse. The calcuations made wtih these assumptions indicate that failure had to occur before the completion of pours scheduled for that day.

7 – Specifications and Contract Documents

7.4 – Comments

The appointment of M. M. Dillon and Company Limited as Consulting Engineers to design and supervise the construction of the Heron Road Bridge was reasonable and proper. This firm of consultants has been in business since 1946, based in London, Ontario and has a wide variety of experience in this type of work. They are one of the few firms retained directly by the Department of Highways of Ontario to provide the full range of consulting services on both road and bridge projects. At the time of their appointment on this project they had successfully completed over 200 separate bridge assignments. We are of the opinion that M. M. Dillon and Company Limited are well qualified and competent in this field. The contract documents prepared by them were complete, explicit and in accordance with standard practice.

The two contract awards were entirely proper and logical. Beaver Construction Company had experienced supervisory personnel and their bid was obviously in line with the other low bidders. They carried out their contract in a satisfactory manner. O. J. Gaffney Limited is a firm associated with the "Gaffney Group" of companies based in Stratford, Ontario. They have a good reputation as bridge contractors and have successfully built numerous bridge projects throughout the Province of Ontario. The appointment of both contractors would have been approved by the Department of Highways who are satisfied that each was competent in their particular field to undertake the work.

The chain of command insofar as the Corporation of the City of Ottawa is concerned with Contract No. 64-78 is:

(1) The Director of Planning and Works
(2) The Engineer or Engineers as the case may be
(3) *To a lesser degree,* the Inspectors
(4) *Remotely*–any approval or inspection by any provincial or federal authorities.

Thus, as is common in most municipal projects of this nature, the final decision of the Director of Planning and Works is final and binding though undoubtedly he would be influenced in any technical decisions by the advice of his consulting engineers.

The latter act more or less as his agents on the project and their recommendations could be overruled. However, on this project there is no evidence that a need for the Director to exercise his prerogative ever arose.

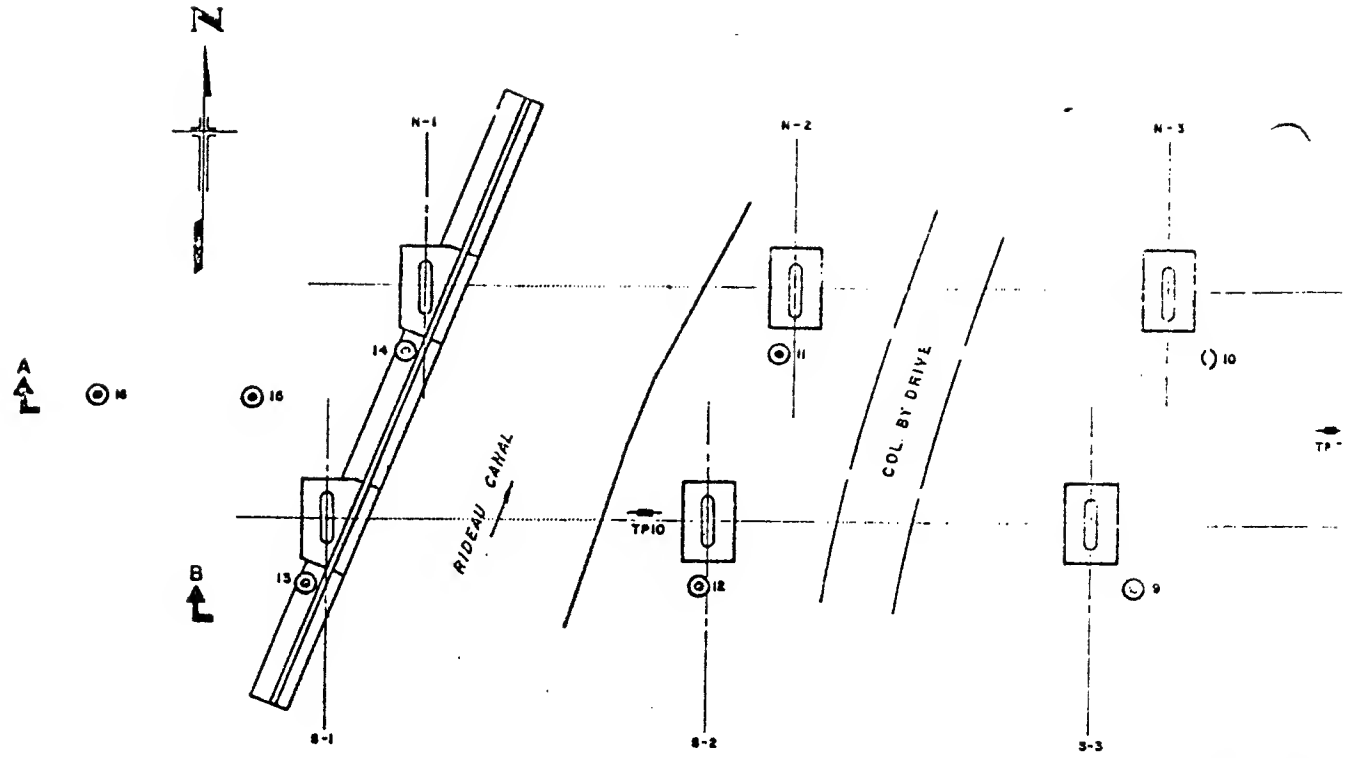
The Inspectors referred to above would be those inspectors directly supervised by the Engineer and would act under his guidance.

The provincial or federal inspectors involved would not be full time on the project during construction but would make periodic visits to the site to ensure that the requirements of the various safety acts and other regulations are being enforced. In the case of the Safety Inspectors, they are empowered to stop construction if they consider work is being done in a hazardous fashion but would be unlikely to express opinions on the structural design of scaffolding or falsework. On a project such as this, where a qualified consulting engineer is full time on the site in charge of supervision of construction, these inspectors are prone to leave matters of structural adequacy to the engineer. Provided the latter is satisfied that the falsework is adequate, the Inspectors would be unlikely to rule otherwise.

The responsibilities and liabilities assumed by the contractor with respect to the performance of the work embraced in the contract are reasonable and in accordance with standard practice.

With respect to the procedure laid down for the design of "Falsework" in Clause 6.4.1 of Contract 64-78, it should be noted that the Engineer has the right the request changes in the structural design of the falsework, but the Contractor is held fully responsible for the performance of the falsework, including design, even though the design as built may differ materially from that originally submitted by the Contractor. Such a requirement is quite standard and conforms to the practice of the Department of Highways of Ontario who could be said to set the basic standards for bridge construction. Clauses of this nature have been incorporated in Bridge Construction Projects for 20 years or more by the Department of Highways and there has been only one other major collapse in that time, due to faulty falsework, though hundreds of bridges have been built. Nevertheless, we believe this present system results in an area of uncertainty whereby a contractor assumes that the engineer will check his, the contractor's design, and the engineer passes comment but expects the contractor to satisfy himself that the design is correct. In the light of this Heron Road Bridge collapse we believe that some fresh thought is necessary on the general "Falsework" clauses contained in most bridge contracts in the Province.

LIST OF EXHIBITS (B)



FOUNDATIC

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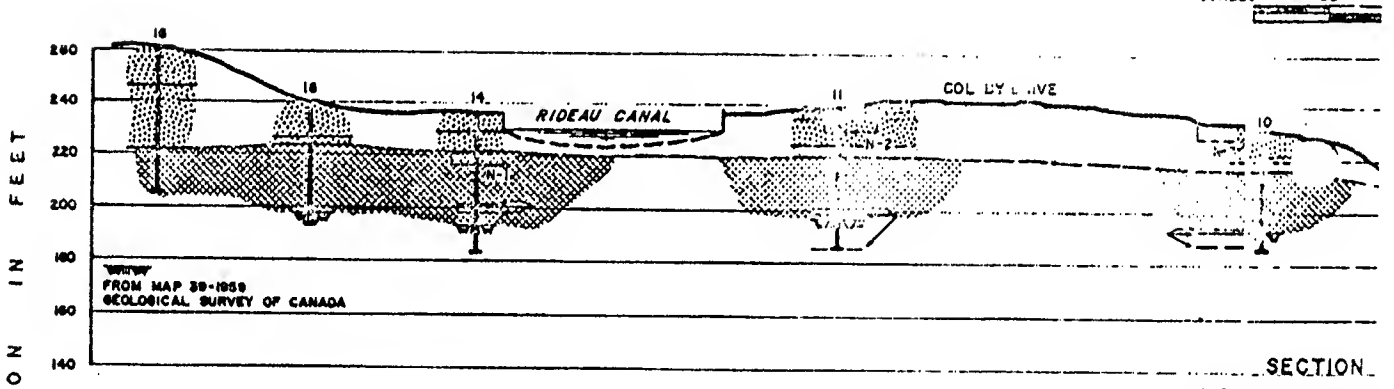

SECTION

NORTH BOREH

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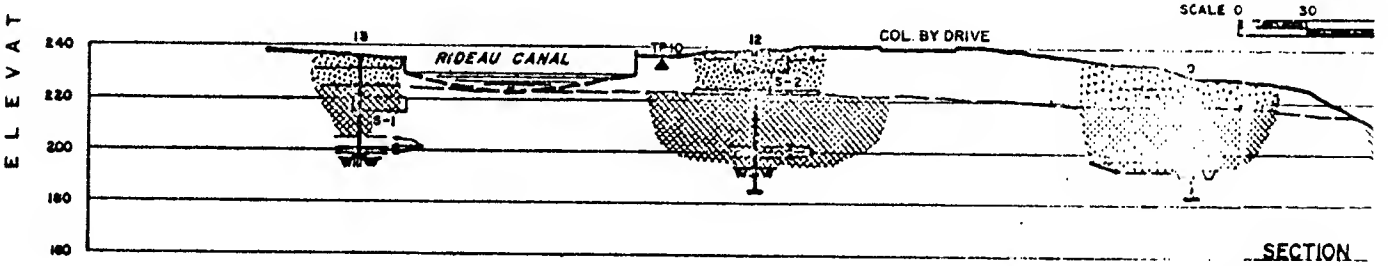

SECTION

SOUTH BOREH

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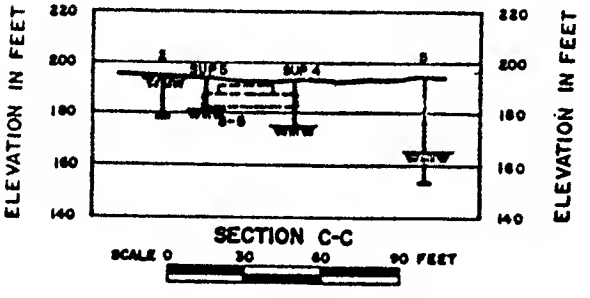


SYMBOLS

PETO
DILLON
ACRES
PROFILE
} BOREHOLES

TPS PLAN
PROFILE
} TEST PIT

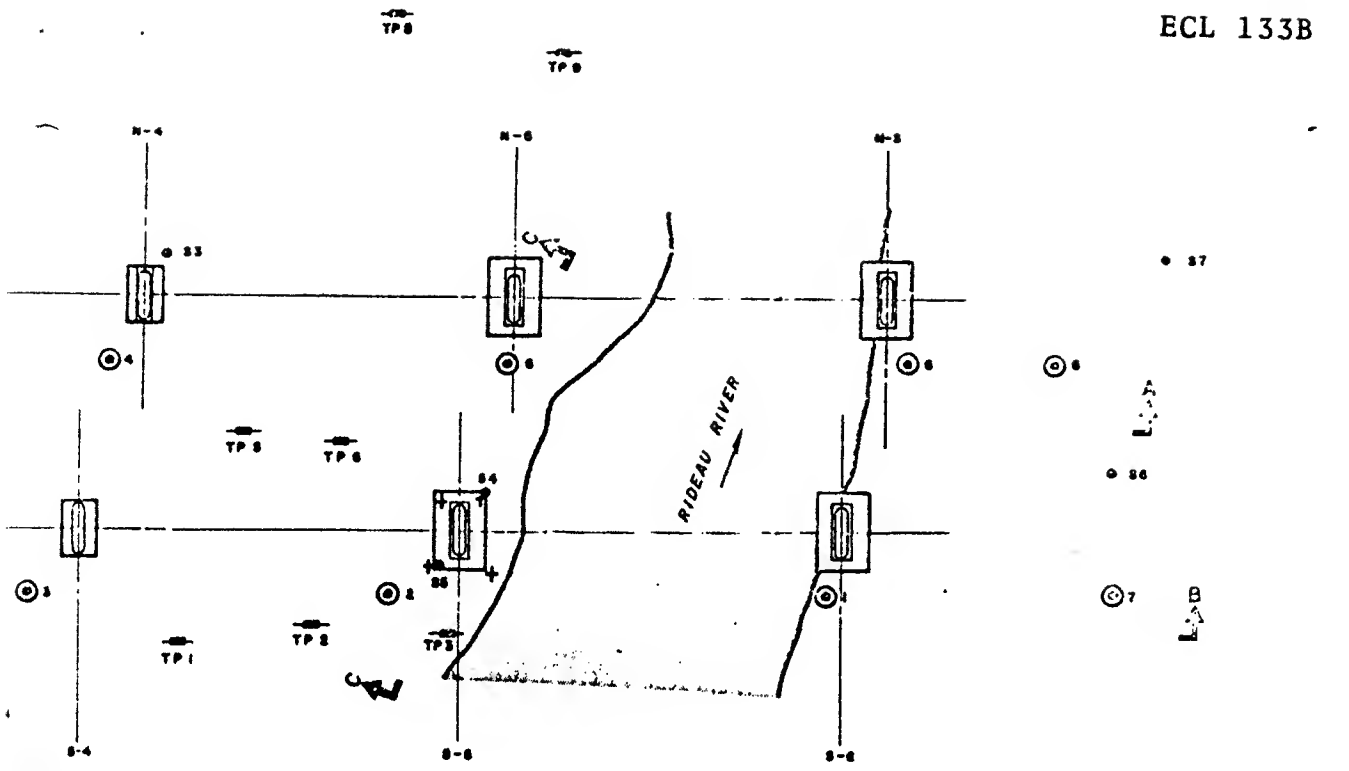
PEDESTAL
PIER FOOTING

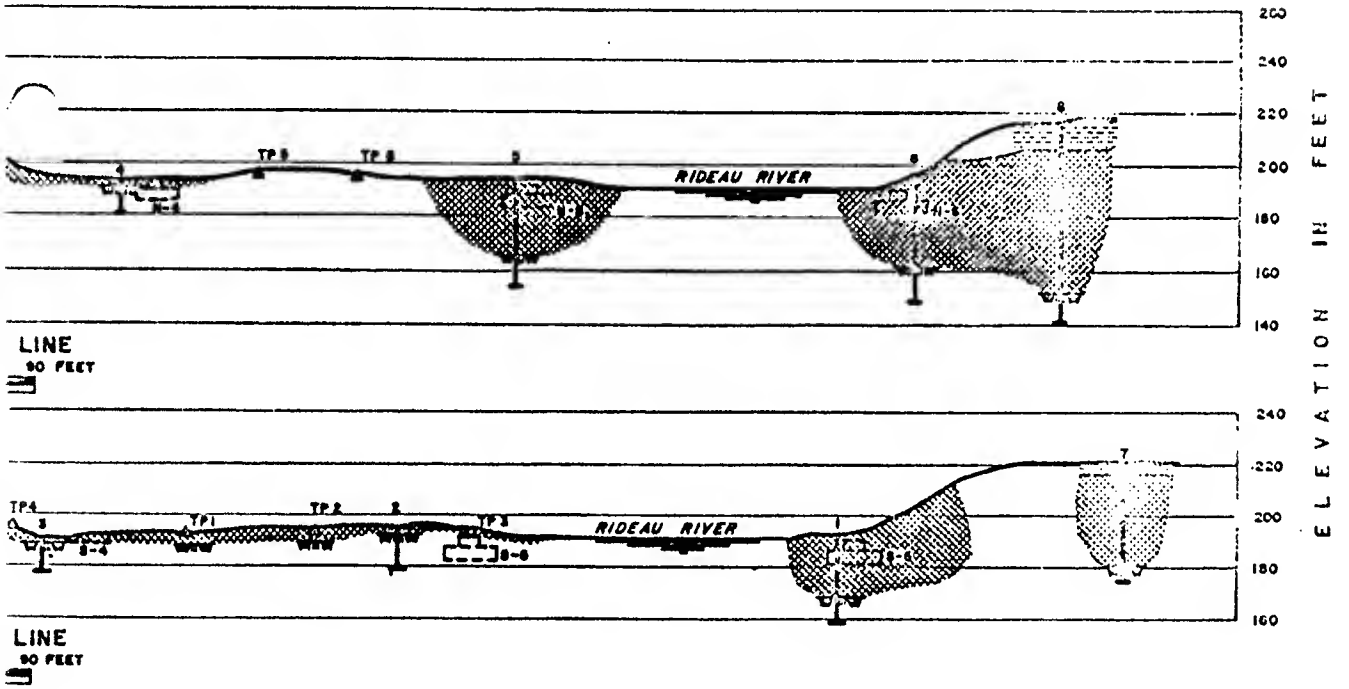
LEASY PENETRATION
MEAN PENETRATION
GREATEST PENETRATION
} PILE TIPS

LEGEND

GREY BRI
TILL
SILT AND
LL

Ex





NOTE

1. PLAN, PROFILE AND BOREHOLE DATA FROM DILLON, JOB 9821-1 DRAWINGS F-2, 3, 4.
2. TEST PIT DATA BY ACRES PERSONNEL
3. SILT IN HOLES 7 AND 8 CONTAIN ORGANIC TRACES
4. TWO TO FOUR FEET THICK LAYER OF MEDIUM TO STIFF CLAY WITH COBBLE SKELETON WAS DETECTED EAST OF PIER 55, AND NORTH EAST OF PIER N8.
5. CONTRACTOR PLACED TWO FEET OF COMPACTED CLAY FILL EAST OF PIER 55
6. RIVER BANKS SHOWN IN LOCATIONS PRIOR TO CONTRACTORS OPERATIONS

REY SILTY CLAY

SILT

t B-1

H.G. ACRES & COMPANY LIMITED CONSULTING ENGINEERS

THE SUPERVISING CORONER OF ONTARIO

INVESTIGATION OF HERON ROAD BRIDGE FAILURE

LOCATION OF BOREHOLES AND TEST PITS AND PROFILES OF FOUNDATION CONDITIONS

DATE NOVEMBER 1958

H. G. ACRES & COMPANY LIMITED

PLATE 3

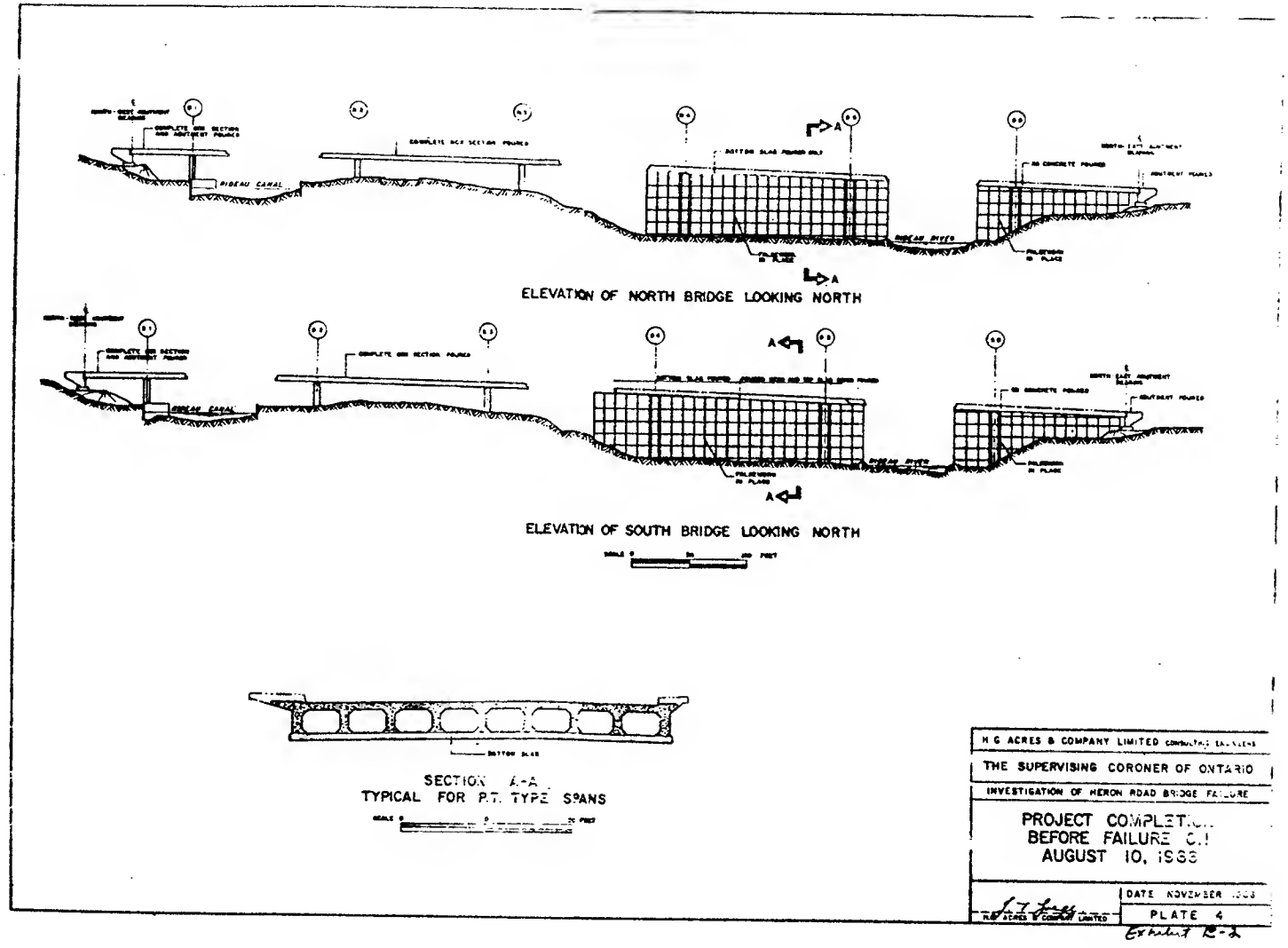
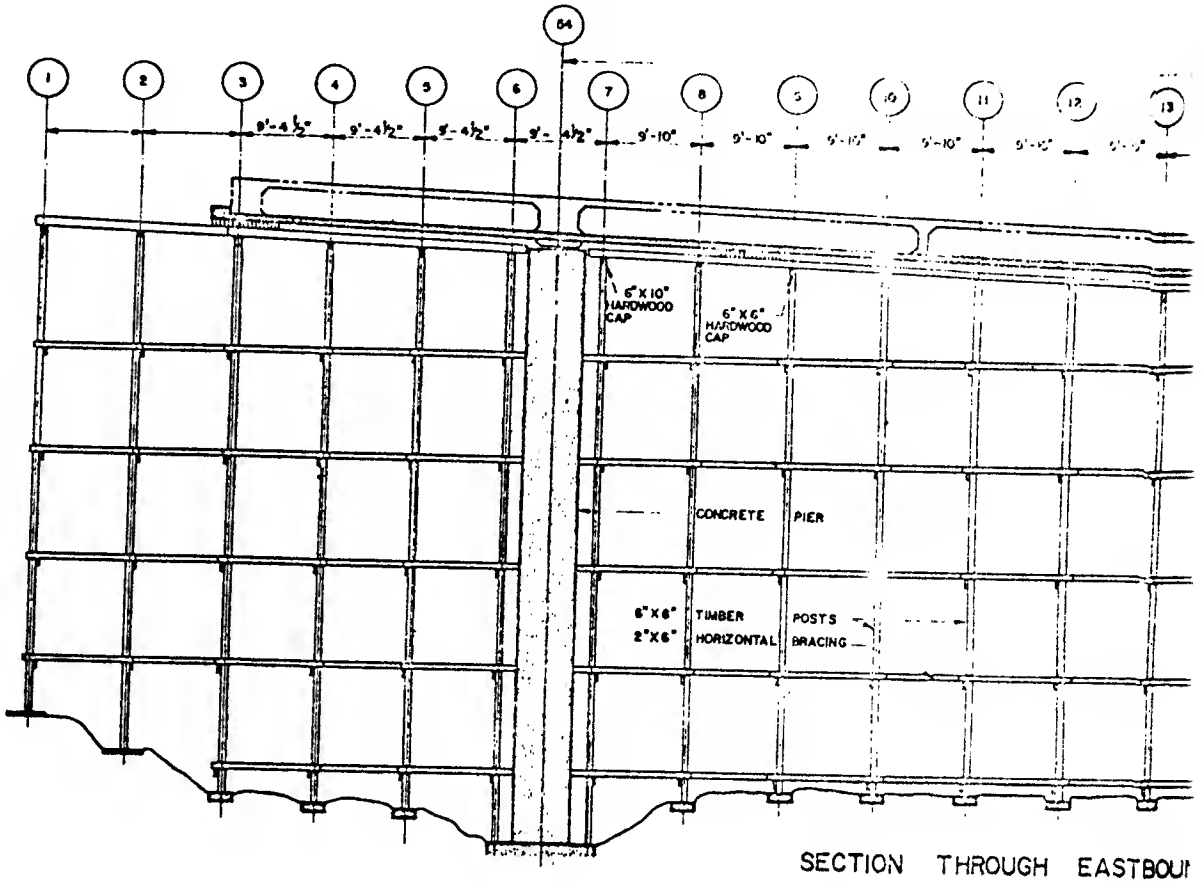
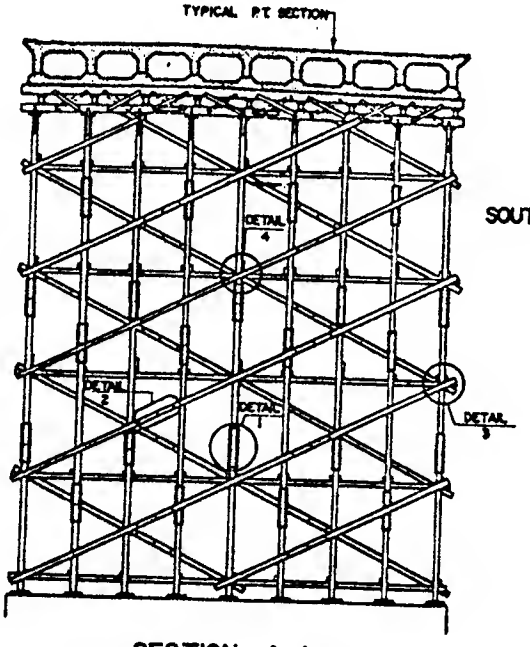


Exhibit B-2. State of Project Completion before Failure on 10 August 1966



SECTION THROUGH EASTBOUI

SCALE 0



SECTION A-A

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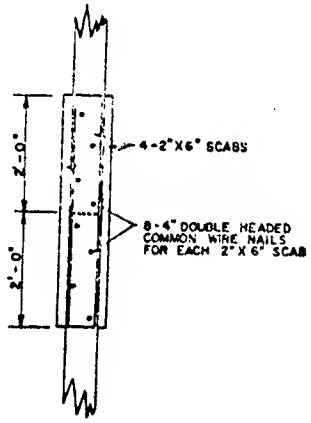
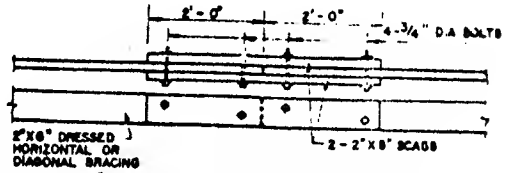


B

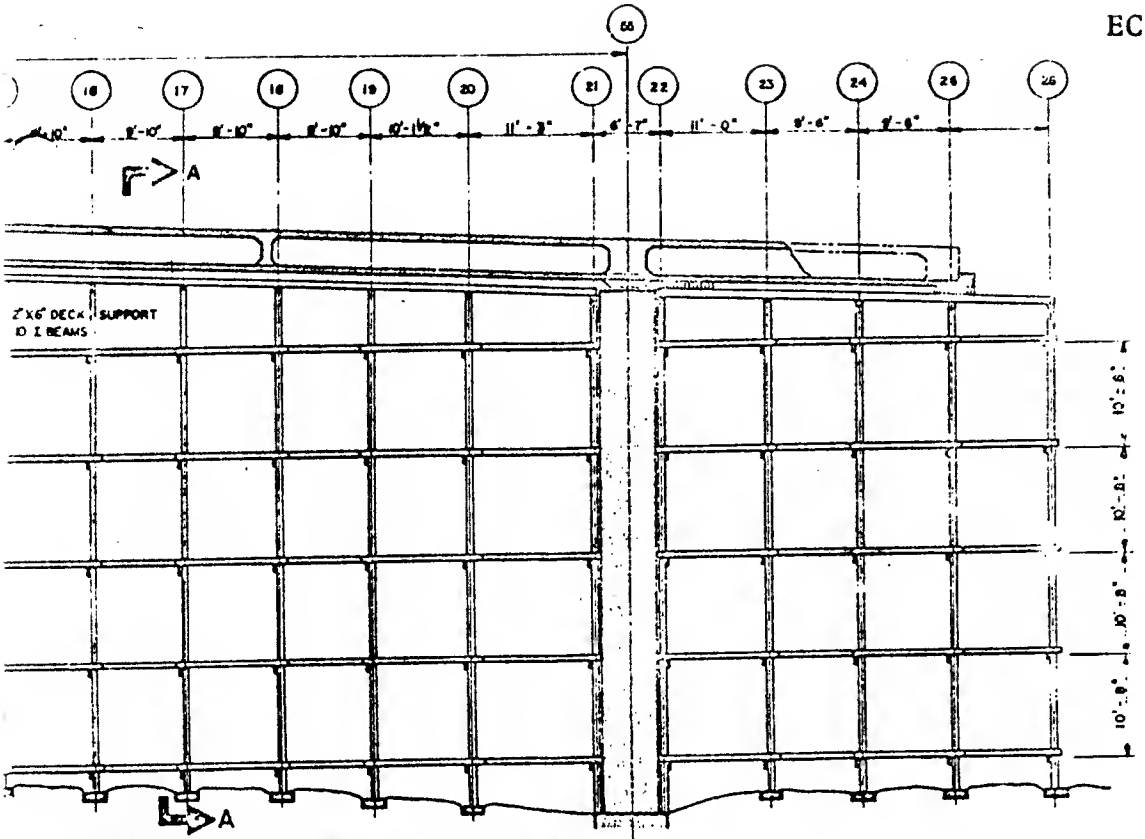
2"X8" DRESS NORTH SOUT HORIZOTAL

2"X8" DRESSE DIAGONALS

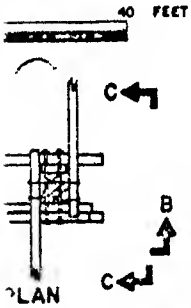
TYPICAL SPLICE-DETAIL 1
FOR 6" X 6" POST



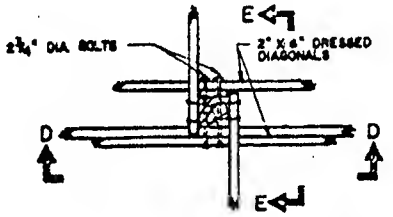
TYPICAL SPLICE-DETAIL 2
HORIZONTAL AND DIAGONAL BRACINGS



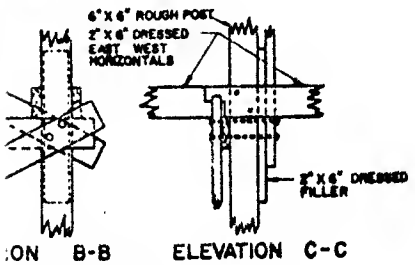
FALSEWORK AND PERMANENT STRUCTURE



PLAN

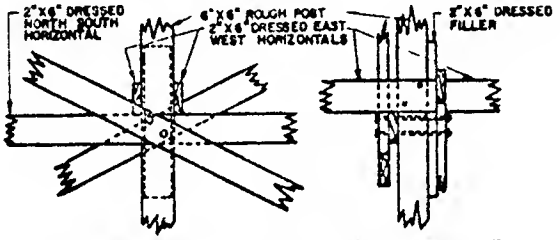


PLAN



ON B-B ELEVATION C-C

EXTERIOR JOINT – DETAIL 3



ELEVATION D-D ELEVATION E-E

TYPICAL INTERIOR JOINT DETAIL 4

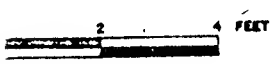


Exhibit B-3

H. G. ACRES & COMPANY LIMITED CONSULTING ENGINEERS

THE SUPERVISING CORONER OF ONTARIO

INVESTIGATION OF HERON ROAD BRIDGE FAILURE

FALSEWORK FOR SPAN P.T. 3S GENERAL ARRANGEMENT AND TYPICAL DETAILS

DATE NOVE... ER ...55

H.G. ACRES & COMPANY LIMITED

PLATE 5

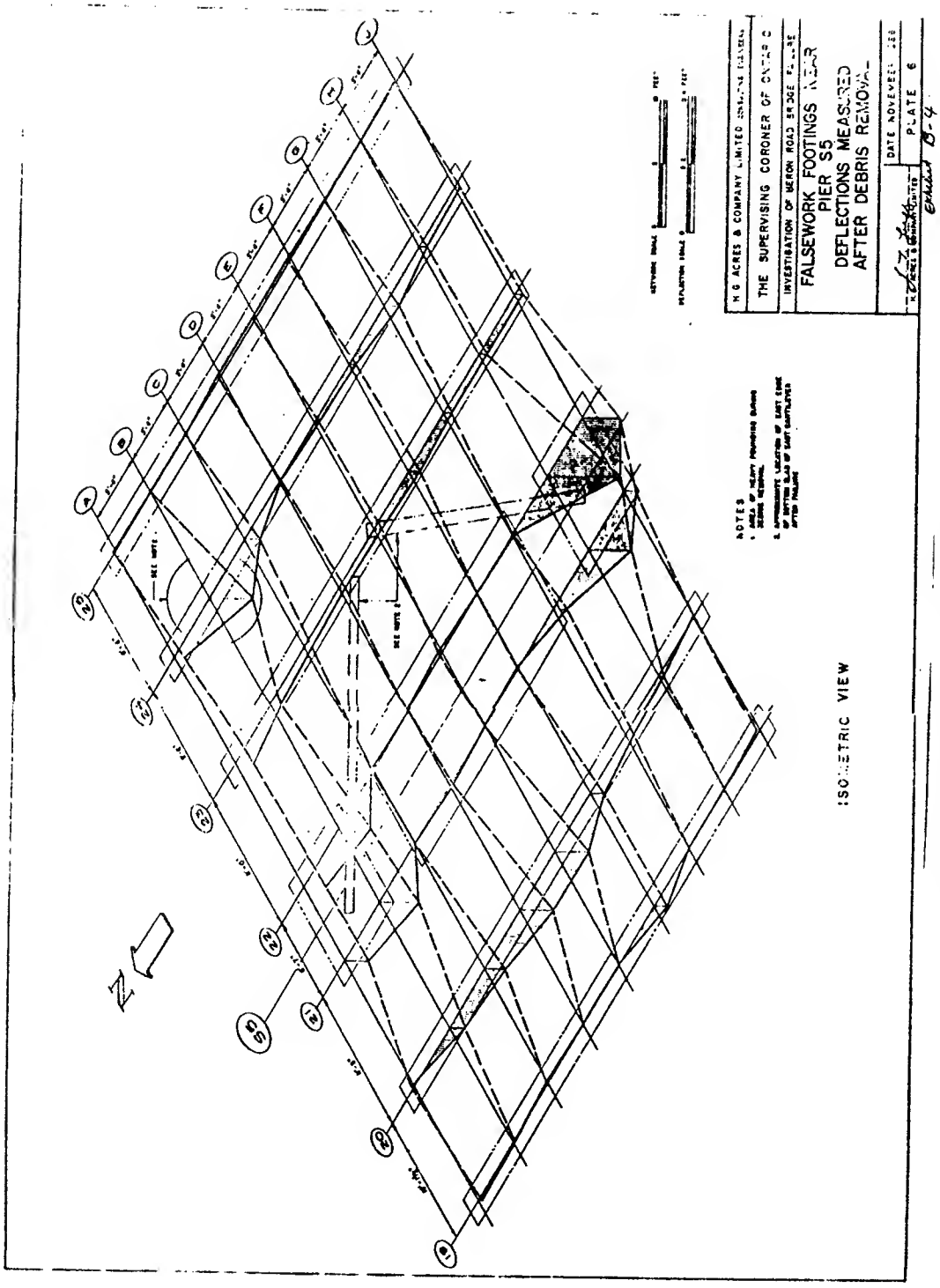


Exhibit B-4. Deflections of Falsework Footings near Pier Measured after Debris Removal

HERON ROAD BRIDGE (B)

APPENDIX

9.04.13 FORMWORK AND FALSEWORK

GENERAL REQUIREMENTS

The Contractor shall be fully responsible for the design and construction of all formwork and falsework. General information on the acceptable practices for the design and construction of formwork (or falsework) is contained in the recommendations of American Concrete Institute Commitee 622 (Publication SP-4).

SPECIFIC REQUIREMENTS

Formwork and falsework shall be erected true to the lines designated in accordance with the plans. The Contractor shall submit detailed plans of the proposed falsework to the Engineer for approval. Four copies of each such plan are required, and they are to be submitted to the Engineer at least 4 weeks before construction of the falsework is commenced. Where the structure involves a railway or navigable waterway, 3 additional copies of each plan are required for submission by the Engineer to the Authority concerned.

Notwithstanding the approval by the Department of any plans or proposals for falsework or formwork, it remains the responsibility of the Contractor that all formwork and falsework is adequate and safe for the proper erection of the work. Any defect in the work, resulting from the failure of the formwork and falsework to satisfactorily support the concrete and all loads superimposed by construction operations, shall be remedied by the Contractor at his own expense to the satisfaction of the Engineer.

Formwork and falsework is not a separate pay item, the cost shall be included in the unit price bid for the concrete item concerned.

DESIGN STANDARDS

The Contractor shall use the following as minimum standards for the design of formwork and falsework.

(i) **VERTICAL LOADINGS**: Normal concrete shall be considered as a liquid weighing 150 lbs./cu.ft. An additional 75 lbs. per square foot of horizontal surface subject to vertical loading shall be added to allow for impact, runways, buggies and the like.

(ii) **HORIZONTAL LOADINGS**: The horizontal loading shall be in accordance with good practice and shall take into consideration the rate of placing, the temperature of the concrete, the effect of vibration of the concrete and the consistency of the mix. An allowance for impact shall also be included with horizontal loading.

(iii) **ALLOWABLE STRESSES**: Timber for forms and falsework shall be designed in accordance with the Canadian Standards Association Specification for Engineering Design in Timber, 086.

The design stresses may be increased 15 per cent for temporary loading. The unsupported length of wooden columns and compression members shall not be more than 30 times their least dimensions.

9.04.13 **FORMWORK AND FALSEWORK (CONTINUED)**

The following permissible stresses are for structural grade timber and include the 15 per cent increase for temporary loading.

STRESSES.	EASTERN SPRUCE.	DOUGLAS FIR COAST.
Bending Stress at Extreme Fibre	1,200 psi	1,650 psi
Modulus of Elasticity	1,100,000 psi	1,600,000 psi
Longitudinal Shear	103 psi	120 psi
Tension parallel to Grain	1,200 psi	1,650 psi
Compression Perpendicular to Grain	345 psi	448 psi
Compression Parallel to Grain, when $\frac{L}{D} = 10$ (or less)	862 psi	1,265 psi

Structural steel used for falsework shall be designed in accordance with CSA Specification S6.

MATERIALS.

Forms and falsework shall be constructed of wood or metal unless otherwise specified, or authorized by the Engineer.

Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plane surface.

Material for wood forms and falsework shall be sound wood in good condition and free from defects which may impair its strength.

Species of timber used for falsework shall be indicated on the falsework plan and unless specified all timber sizes shall be considered dressed.

FALSEWORK

Falsework shall be defined as the structural supports and bracing for the forms.

Hardwood wedges or screw jacks shall be used to adjust the forms to the proper height and to correct any settlement either before or during the placing of concrete.

Bracing material shall consist of 2-inch by 4-inch timbers minimum. Bracing shall be nailed to each post with at least two 4-inch nails. Splicing of bracing will not be permitted. Where timber bracing for steel posts is used, the ends of such bracing shall be fastened to steel posts in an approved manner.

All wood posts shall be of solid timber, free from chips, splits and warps. Posts shall preferably be cut to the full length required.

Where splicing of wood posts is necessary, the cut must be made absolutely square to ensure a full bearing area.

9.04.13 **FORMWORK AND FALSEWORK (CONTINUED)**

Scabbing over the splice on all four faces of a square post shall be provided. Each post shall be braced in both directions both above and below the splice immediately adjacent to the scabbing. Splices on adjacent posts shall be staggered.

Splicing of round posts will not be permitted.

Where any pile in a falsework pile bent is too short a propertly designed pile splice will be permitted only on the approval of the Engineer. The use of short lengths of timber to make up the required length of pile will not be permitted. In lieu of a proper pile splice, all the piling in the bent shall be cut off to the same elevation and capped. An extension bent shall then be constructed.

All caps should be made continuous for the entire length of the bent. Where splices are necessary, they shall be located at centreline of a pile or post.

Falsework shall be supported on mudsills, concrete foundations or piles. The size of mudsills and concrete foundations shall be determined by the load and load bearing capacity of the materials on which they are placed. On completion of the work concrete foundations and mudsills shall be removed; piles shall be cut off two feet below the finished grade, ground level or bed of stream.

Generally, falsework over fill shall span over the fill or be supported on piles driven into the original ground. Mudsills or concrete pads on fill will not be acceptable unless the fill material is capable of providing good bearing and will not be subjected to damage by water or frost.

The slope of such fill shall not be greater than 1-1/2:1.

Piles used to support the falsework shall be driven in accordance with the specification for bearing piles as outlined in Section 9.03.

Unless otherwise specified, single slab or girder spans shall be constructed with a permanent camber at midspan equal to 1/40 of an inch for each foot of span length, proper allowance being made for settlement.

Where the falsework is supported on timber or steel beams over a long span, allowance for the deflection of such beams shall be made. The deflection diagram shall be shown on the falsework plan.

HERON ROAD BRIDGE CASE

Think Questions

PART B

1. Does the format of the H. G. Acres report seem the best for the purpose?
2. Do the conclusions and recommendations lay the blame for the failure on anyone?
3. What is given as the reason for failure?
4. Exactly how was the falsework braced to the piers to prevent movement in the east-west direction?
5. What is stability?
6. From the data given can you estimate the structural strength of the falsework?
7. What would diagonal bracing in the east-west direction contribute to the strength of the falsework?
8. Considering the chain of command given in section 7.4 who should bear responsibility for the collapse?
9. What is the purpose of such a report? Does this achieve the purpose?

HERON ROAD BRIDGE (C)

Part (C) of this case describes the proceedings of the Coroner's Inquest and excerpts some of the more important and revealing testimony. Reasons for the lack of sufficient falsework bracing are investigated; the involvement of the consulting engineers, contractors, and safety inspectors is demonstrated; and the responsibility for the faulty falsework is suggested by the Coroner's Jury.

HERON ROAD BRIDGE (C)

Editorial

November 24, 1966
from Journal

Five men have been sitting each day this week behind five aldermans desks. They are the coroner's jury listening to the evidence into the death of Clarence Beatty. Eight other men died with Clarence Beatty when the Heron Road Bridge collapsed on that terrible afternoon last August. They are not mentioned in the jury's terms of reference but in trying to examine why one man died, the jury is dissecting the whole disaster. The coroner's jury is a court presided over not by a judge, but by a medical doctor, the chief coroner of Ontario, Dr. H. B. Cotnam. The court is called formally to order, all rise when the coroner enters and leaves. Witnesses swear to tell the truth, the whole truth, a roll call of the jury is taken each day, and the coroner is formally notified that all are present. But as one witness after another comes forth to give his evidence, it is clear that this is a court unlike any other. No lawyer jumps up to raise objections though many are present. The witness is encouraged to given what is in another court "hearsay evidence." Dr. Cotnam will turn to a witness who has been led through his testimony and will ask as if privately and confidentially, "why do you think the bridge fell down." The jurors themselves have the right to ask questions of each witness and usually in this case at least, they do.

No inquisitional air hangs over the council chambers. Witnesses seem remarkably at ease, thanks to the humane and business-like way Dr. Cotnam runs his court. Coroner's jury only recommend and their findings are in no way binding on anyone. Some critics have urged that specially qualified persons be chosen as jurors, a suggestion which merits respect. Others have advocated putting some teeth in juror's findings or doing away with the system altogether. But the way the inquest into Clarence Beatty's death has been conducted, the fullness of the testimony and the apparent freedom of the witnesses to tell all they know of the accident is a considerable argument for the usefulness of this old institution.

The coroner's jury is an instrument of seeking knowledge into the cause of death without revoking the full of either criminal or civil court action. They may always follow after. If there is no grounds for prosecution the public has at least the opportunity of seeing why not.

It is hard to believe the 5 men serving on the jury will not have some specific find to make. When the last witness is heard, the public ought to have a much better idea of why Clarence Beatty died.

Bridge Collapse Inquest Opens

November 21, 1966
from Journal

The Toronto engineer who supervised the investigation into the Heron Road Bridge collapse here August 10th told a coroner's inquest today that sections of the falsework supporting the span were not connected to the adjoining pier. Terrance Gregg was the lead off witness at the inquiry headed by Ontario chief coroner, Dr. H. B. Cotnam.

Using an 8 foot model of the adjoining bridge section, Mr. Gregg pointed out that all the wooden bracing was installed laterally. None was horizontal. He

illustrated the effect by shoving the model from one side. It remained rigid. Then he pushed it from the one end and the model shook. A member of the 5 man coroner's jury asked Mr. Gregg whether the falsework bracing should normally have been connected to the adjoining pier. "I believe it shoud have" Mr. Gregg replied. Dr. Cotnam said in opening the inquest that jurors would hear a great deal of highly technical and conflicting evidence. He said the pre-inquest investigation had been one of the most extensive and thorough ever carried out in Canada. The investigation has cost more than a hundred thousand dollars. "And we want to get a hundred thousand dollars worth of value out of it."

November 21, 1966 from Journal

Eyewitnesses

Eyewitness evidence was heard Monday from 25 men, many of them seriously hurt in the disaster. About 40 eye witnesses were released because evidence was becoming repetitous.

A crane operator's helper heard what he thought was the sound of wood cracking about 15 minutes before a span of the Heron Road Bridge collapsed.

John Robillard told the inquest he was climbing a ladder to the top of the span when he heard the sound. He said he believed it was only construction noises and thought nothing of it, but about 15 minutes later, "I felt a sliding motion and everything went black." He plunged 60 feet amid the debris and woke up in the hospital with back and pelvis injuries.

Gaetan Lacroix of Orleans, the helper on a crane for Hurtman Bros., was cleaning the floor of a crane when the bridge collapsed. "I heard the noise of wood cracking," he said "When I heard the noise, I turned around and saw the bridge falling and posts buckling toward the west side." He said the falsework was bending at the joints and, pointing to an 8 foot model of the bridge, indicated that the falsework started to give about half way up the structure. He said the falsework bent about 5 or 6 inches before the bridge fell.

Andrea Perrier of Mason Quebec, who was carpentry foreman in charge of the framework, said that in his opinion, the falsework was strong enough to hold the span. Mr. Perrier said he built the falsework according to drawings given to him by officials of the construction company and that no one complained to him at any time about it. He also told the inquest that Leonard Baird, a consulting engineer, who was killed in the disaster, had approved his work.

Witnesses were questioned relentlessly by special crown council, Herb Langdon, on the basic behavior of the falsework and the direction in which the concrete superstructure fell during the collapse.

from Journal

George Humphreys, President and Chief Engineer of M. M. Dillon Company, said the collapse of the bridge may have been brought about by 1 of 3 factors. Inadequate posts, a small amount of settlement in the ground, but he named the lack of longitudinal bracing as the major cause.

Mr. Humphreys said his attention was drawn to the bracing on a span to the west of the one which collapsed when he visited the site in the fall of 1965. The span which collapsed had not been built at that time. "I was a little concerned about the bracing, whether it was adequate or not."

The city drew the falsework to the attention of Victor J. Bromley, project engineer, who was responsible to the consulting firm for the design of the bridge. He said the consulting firm's resident engineer, Leonard Baird, who was killed that day, was in on the discussion.

"I observed the falsework and questioned the system of bracing and noted the absence of longitudinal bracing" said Mr. Humphreys. "Bromley informed me that the tension of the falsework was braced to the piers as an alternative to longitudinal bracing," Mr. Humphreys replied. Mr. Langdon asked who was responsible for the design of the falsework. "The Gaffney Construction," Mr. Humphreys replied. He added that the consulting firm does not have the right to order specific changes. "But we can call in inspectors to stop the work if we think it is not safe," he said. Mr. Humphreys also said he believed the falsework was approved by Mr. Bromley. "But I don't know if he saw it on or not."

Oliver J. Gaffney, president of Gaffney construction company of Stratford, which held the construction contract for the bridge, testified under the protection of the Canadian Evidence Act. Crown Counsel Herbert Langdon asked Mr. Gaffney if it was correct that his company was assuming some but not all the responsibility for the collapse. "Yes," was the answer.

Chief coroner Cotnam then put the same dramatic question to Mr. Gaffney that he had earlier put to Mr. Humphreys. "Why do you think the bridge fell down?" Mr. Gaffney said there was probably more than one cause. He didn't think there was any one weakness of sufficient importance to be held out as the main cause of the collapse. He said the first designs for the bridge falsework had been changed after Victor Bromley, engineer with the Dillon firm, suggested changes. Under further questioning, Mr. Gaffney said he hadn't been aware that Richard R. Brock, an engineering student employed for the summer as an instrument man on the project, had dealt with two safety inspectors who were complaining about the falsework.

A Picture of Human Error Emerges

November 23, 1966
from Citizen

With cause and responsibility beginning to emerge like film images in a developing tank, witness after witness sought protection of the Canada Evidence Act at the Heron Road Bridge inquest here Tuesday.

(Under the act persons testifying at any court hearing cannot be prosecuted later in another court on the basis of, or by the use of, that testimony. There is not, however, any protection against perjury.)

Tuesday, the real "meat" of the inquiry, testimony of the engineers and other officials involved in the multi-million dollar bridge construction project, held the center of the stage.

Most of the engineering experts called so far have agreed that the falsework was not constructed according to laid down specifications and that the wooden structure simply was incapable of supporting the tons of concrete poured into the fatal span.

As yet, no one individual has pointed an accusing finger at anyone else. But the mass of evidence itself already has made it obvious that some person, or persons, erred gravely.

And as these men testified, the name of a witness yet to be called, that of young Waterloo University engineering student, Richard R. (Ricky) Brock, kept popping up continually. Brock worked at the Heron Road Bridge site as an instrument man during last summer's school holiday. Primarily his duties, said officials of the Gaffney firm, were those of any instrument man, using level and transit where these were needed on the job. But, some of these same officials admitted young Brock at times assumed roles approximating that of assistant engineer.

It was to Brock that city and provincial safety inspectors went last summer to ask whether the falsework on span 4-S was adequate to support the tons of concrete it must stand up under. In respect to this, the bridge project manager, Oscar L. Ellison, said that young Brock had mentioned the inspector's inquiry to him.

Ellison, whose formal education ended with four years of high school, said Brock informed him briefly of the incident and had told him at the time that he (Brock) assured the inspectors that the falsework construction met with full approval of the consulting engineer, M. M. Dillon and Company.

Crown Counsel, Herbert Langdon, of the attorney general's department, probed deeply into this phase of the Ellison testimony. "So," said Mr. Langdon, "you knew sometime in July that safety inspectors had questioned the design of the falsework?"

"I did not discuss the matter in detail with Brock," replied Mr. Ellison.

"But, would it not be fair to say that Brock told you the inspectors had questioned the safety of the falsework?"

Mr. Ellison cleared his throat and took a long moment to think before replying, "Yes I guess that would be a fair statement."

Mr. Langdon, deep-voiced and barrel chested, rumbled, "And you took no steps to discuss or bring this matter to the attention of anyone in the Gaffney or Dillon Firms?"

Ellison said he had not.

"And why not?" asked counsel.

Ellison, his mouth pressed almost against the face of the witness stand microphone, his deep breathing clearly audible over the public address system, explained that he had not really regarded the inspectors inquiry as anything more than a request for "our opinion."

"Wouldn't that amount to the same thing?" asked Mr. Langdon.

"No," said Ellison, "I can only say that it didn't come to me as anything in the terms of an inquiry, anything more than a request for an opinion."

"But," counsel pressed, "you did nothing about it, is that right?"

"No, sir."

"And you were the person directly responsible for the job?" Ellison nodded his head.

from Journal

Mr. Ellison told the inquest that the falsework was discussed repeatedly at a number of site meetings attended by Victor J. Bromley and Leonard Baird, engineering officials with Dillon consulting firm in addition to himself. Mr. Ellison said that a few days prior to the pouring of the first deck on the bridge they had agreed the falsework was alright.

Mr. Ellison said there was never any mention to him by anyone about a deficiency of longitudinal bracing in the falsework. Longitudinal bracing has since been installed in the falsework on the north span which remains standing.

from Citizen

He then went on to describe the actual collapse of the span. He was up on top when it occurred. He felt or heard nothing unusual until he felt himself falling.

"I came to on the ground and I ended up in the hospital," he said.

Dr. Cotnam directed a few questions at the witness when Mr. Langdon concluded his inquiries. The former Pembroke physician, courteous, alert, and direct in his manner, asked quietly, "Can you offer any opinion, Mr. Ellison, as to why the bridge fell?"

Ellison replied quickly, "No, I have no opinion at all." His voice was now so low even through the microphone, that he had to be asked to repeat his answer. Then he added as though expressing an afterthought, "I felt pretty safe up there that day; I have no opinion now."

Earlier, the bridge project manager described tests which had been made prior to construction of the falsework to determine whether the ground was suitable to bear the weight of concrete "pads" which were to form a base for heavy wooden piles. He described, in lengthy detail, how a big hydraulic jack was used to compress the ground under twice the weight which would actually be required. The jack pressure, he said, was applied steadily for a period of 72 hours, and the results showed a "give of only .075 inches."

from Journal

Bernard J. Houston, chief estimator for John Gaffney Company, said he was responsible for the majority of the design calculations for the bridge and that it was all done by him or under his supervision. He told the inquest that the final design was an accumulation of his efforts and those of Mr. McTavish.

from Citizen

Three separate sets of plans for the falsework had to be drawn up and presented before the consulting engineers (M. M. Dillon and Company) would accept them. And the third and final was accepted only after some "amendments" were made, he said. The acceptable plan included the use of diagonal, horizontal and transverse wooden bracings, short piles, and posts.

But when it was discovered that, because of extensive rock areas at the site, short piles could not be driven into the ground, it was decided to use concrete pads as a footing at the western end of Span 4-S, and short piles at the eastern end only, near the Rideau River. The ground tests were then carried out and the new plan was found feasible by the consulting engineers.

from Journal

Mr. Houston said part of the final plans were drawn by Mr. Brock under his supervision and added that he did not check at the site to see if the falsework had been built according to his plans. He said Mr. Ellison, the senior man in the field, was responsible for that. Mr. Houston explained he had designed falsework for about 15 other structures but never one as high as the Heron Road Bridge. Mr. Houston visited Rogue River site also. "We wanted to see if there was anything we overlooked," he said, adding that there was little difference between the two structures. Asked directly what he thought was the main reason for the collapse of the bridge by Ontario chief coroner, H. B. Cotnam, Mr. Houston replied, "I'll leave that up to the experts."

from Citizen

Robert J. McTavish, chief engineer with the John Gaffney firm, said he became involved in the Heron Road Bridge construction details in January, 1965. He said Richard Brock had done some of the drafting work on the falsework plans.

from Journal

Mr. McTavish said the first proposal was dropped because the piling could not be pounded into the ground because of large boulders in the river bed. He said shorter pilings were tried at the second proposal but they experienced the same difficulty. A plan to use pilings in combination with concrete pads for a base was finally decided upon with the final minor changes to reinforce the concrete base pads.

Diagonal bracing in a longitudinal direction had been incorporated in one of the previous designs but was absent in the third proposal.

from Citizen

He bore out Mr. Houston's testimony with respect to the rocky condition of the site and said that when the final falsework drawings were completed they were approved by Victor Bromley, project engineer and senior official on the job.

McTavish said he visited the site on June 2 of this year and after examining the falsework on span 4-S, he asked for the "continuity of steel beams from one end to the other. I wanted them blocked into the piers, blocked in tight." He wanted this done, he said, because of a "slight slope" in some of the beams in the center of the span. "They were off plumb." He also asked that posts be tied by metal rods imbedded in the cement.

from Journal

Mr. McTavish also suggested that the first deck be poured in its entirety to give the falsework more rigidity. The engineer said he "understood" that all of these things were carried out.

Mr. McTavish said he had for some time been interested in the construction system used in falsework at the Rogue River Bridge (near Toronto) and that he was "pleased and satisfied" to see that the Heron Road Bridge falsework was almost identical. There was no longitudinal bracing used in the Rogue River falsework, he said, "and that bridge did not collapse."

John J. Hallam, describing himself as "contract manager" for O. J. Gaffney Company, said he was not an engineer, but had graduated from the Ryerson Institute after first getting his junior matriculation. He worked directly under Oscar Ellison on the bridge project here but went to McTavish and Houston "when engineering problems arose."

Hallam said he believed the final plan for the falsework originally had included the use of longitudinal beams, but that the design actually used in building the falsework and approved by project engineer Bromley, had no longitudinals.

The day the bridge collapsed Hallam was up on top at the northwest corner. He said, "When it began to go, I didn't know whether I was off-balance or whether the bridge was moving. I took a step to verify what was happening and I didn't remember anything else." He was taken from the tangled wreckage and spent the next eight weeks in hospital.

"Why do you think the bridge fell down?" asked Dr. Cotnam.

Hallam said, "I don't know."

"You hadn't been cutting any corners in order to make a deadline?"

"No sir, I had not," the witness replied firmly.

Inspector Passed On Bridge Falsework

November 23, 1966
from Citizen

"If it's good enough for them (the Consulting Engineers) it's good enough for us." Richard Brock, 22 year old engineering student, testified at the Heron Road Bridge inquest today that those words were uttered by City Inspector, Oswald E. Andrew, after he had inspected the bridge falsework prior to the collapse last month. Brock, who attends Waterloo University, says he was an instrument man on the Heron Road Bridge construction.

Some time in May of this year, he said Safety Inspector Andrew and Ontario Labour Department Safety Inspector, Robert Kerr, had come to inspect the falsework. As there were no officials available at the time, Brock undertook to escort the officials on their inspection tour. He described certain things which the inspectors found; all of them a minor nature such as insufficient number of nails in some of the joints. Brock said they suggested additional scaffolding might be required and that some of the ladders leading to the top of the falsework at span 3S, the fatal one, should be roped at the top to make them more secure.

They went back to the O. J. Gaffney office after the inspection and asked Brock whether, in his opinion, all the specifications pertaining to the falsework had been adhered to. Brock replied that the plans had been approved in full by M. M. Dillon, Consulting Engineering Firm. Brock says that a report was then prepared by two inspectors, and he was asked to add his signature to theirs.

Earl Langdon suggested that there had been some sort of doubt in Andrew's mind with respect to the safety of the falsework construction. The young engineering student replied quickly, "Surely, if there was any doubt of the falsework, Mr. Andrew would have mentioned it in his report. He did not do so." Mr. Brock, testifying at the inquest, requested for himself protection of the Canada and Ontario Evidence Act.

Brock started working for the Gaffney Construction Company in January, 1966. He was hired as an instrument man, but for one week on the night shift

from Journal

was acting in the capacity of the foreman. He also worked in the construction company's Stratford Office, and he had drafted part of the plans for the falsework which collapsed, but was under the supervision at all times of Bernard H. Houston, chief estimator of the John Gaffney construction company.

The inquest was told Mr. Brock had passed a drafting course at Waterloo with an A, the highest mark attainable. He said there were no diagonal bracings in the longitudinal direction in the final plans which were approved. He said he didn't know why the bracings were omitted.

The youth said he came on the site of the Heron Road Bridge at the end of April and was there for the entire construction of the falsework. He said that at all times during the construction the falsework was examined by officials of both the construction company and consulting engineers. All the safety recommendations in the safety inspector's report were implemented, and several of the company officials were informed of the visit.

Thomas Sloan of Cornwall, general foreman on the site for Gaffney, who was in charge of the construction of the falsework, testified the falsework was constantly inspected by himself, Mr. Ellison and the officials of the Dillon Company. He said the falsework was approved by the Dillon Company before the first concrete pouring. "I think it was Victor Bromley, project engineer for the consulting engineers, who approved it."

from Citizen

J. H. Kearney, a Civil Engineer and Project Manager of the Heron Bridge site, said it was his firm's general overall responsibility to see that the client's (City of Ottawa) construction requirements were carried out. He then read a paragraph from the contract entered into by the City and O. J. Gaffney Limited which reads, "detailed drawings of the falsework shall be submitted to the Engineer (City) for approval, but such approval shall in no way relieve the contractor of his responsibility under the contract for successful completion of the work."

Kearney said that during the early stages of the falsework construction on one or two of the spans he had noticed that the bracing had been put on in both a haphazard way and in such a manner that it could not be readily checked. Later in the summer he found that the work was of a "much higher quality."

November 23, 1966
from Citizen

Engineering Takes Blame

A thirty-nine year old engineer who said he had "struggled for months to ensure construction safety features" admitted Wednesday that he blamed himself for the tragic Heron Bridge collapse. John Bromley, who came to Canada from Rhodesia in 1964, said he had failed to note the absence of diagonal longitudinal bracing in the falsework of the span which crumbled without warning. Bromley told the jury, "My mind must have been a bit confused at the time. I cannot understand it myself."

He was trying to explain how he as project engineer could fail to see that the bracing laid on by the consulting engineers had not been built into the falsework. Well built, ruddy cheeked and bald, Bromley took his seat in the witness box. He was the 54th witness to be heard.

He either spurned or completely forgot the protection of the Canada Evidence Act, and speaking with a slight lisp, he began by stating that he was man in charge of structural design work in Ottawa with the consulting engineering firm, M. M. Dillon Co. As such, he said he became project engineer of the Heron Road Bridge when the City engaged his firm to see that the structure built by O. J. Gaffney Co. was strictly in accordance with the final drawings and plans. It was his sole responsibility, he admitted, to see also that the work was carried out in a safe and competent manner.

When the original designs were submitted by the contracting firm, Bromley had questions on most features and changes were subsequently made in the design. One change he demanded was the incorporation of the posts into the falsework, and these were to be braced at both ends to support the tremendous weight of the concrete to be poured. At that time, he felt the designs submitted by the contractors did not allow sufficient strength to carry the load. As a result, a revised plan for the falsework was finally submitted after others had been rejected. "The construction had to be safe; that was our (Dillon's) responsibility," Bromley said. It was agreed that diagonal longitudinal posts were to be used at the base of the falsework; but when it became evident that these could not be driven into the ground to the proper depth because of extensive rock, they were abandoned to be replaced by concrete pads to support the upright posts. The falsework itself was to be locked tight to the concrete piers already completed.

Three designs were submitted for the falsework and the third with provisions for the foundation was eventually approved by Mr. Bromley. The second design had incorporated the diagonal bracing but for some unexplained reason the third design did not. *from Journal*

Last spring the final drawings were submitted to M. M. Dillon Company and approved, Bromley said. Herbert Langdon asked whether the design showed the diagonal longitudinal bracing which was ordered. Bromley said he had not looked specifically for this; after all, he said, "We have struggled for months with Gaffney to have the bracing incorporated." It was not until he had studied the drawings closely, following the fatal collapse, that he realized there were no such bracings incorporated into the drawings, he explained. Bromley said that because of a number of other duties he was needed mostly at his office in Ottawa and managed to visit the construction only once a week, and he would spend an hour or two overseeing the construction generally. *from Citizen*

Mr. Langdon's examination became more pointed. Bromley's voice faltered at times and there were fleeting glimpses of anguish on his face particularly when the name of resident engineer, Leonard Baird, was mentioned. Baird was killed in the collapse.

The project engineer testified that at no time was the absence of diagonal bracing mentioned to him by his resident engineer Leonard Baird, or by anyone else. *from Journal*

"I assumed that you looked carefully at the falsework," said Mr. Langdon, "that was one of your responsibilities was it not?"

"Yes, I assure you I certainly did look at it."

"Then," moved Mr. Langdon, "why on earth didn't you notice the absence of diagonal longitudinal bracing."

"I didn't notice, but I cannot explain it."

Mr. Langdon persisted, "But, it was your duty to see that the project was constructed by safe means, wasn't it?" Bromley's reply was inaudible save for the words "not definitely." "Then, you didn't notice that the bracing had been omitted? Why didn't you?"

"My mind must have been confused at the time," Bromley answered, "I cannot understand it myself. I consider this a criticism of myself."

Dr. Cotnam, himself, probed further for answers at this stage. "You only went out there once a week," he said, "and this went on for 5 months." Bromley said that it was correct. "But even during those visits in which you say you inspected the falsework you never realized the bracing wasn't there."

"I hold myself guilty for not having noticed it," the Engineer replied quietly.

Mr. Langdon then referred to a conversation Bromley had engaged in with another official of the Dillon firm, George Humphrey, just a few hours after the collapse. "You mentioned to him that the posts were to have been tied into the piers and that this had not been done, didn't you?" Bromley nodded his head. "So," said Mr. Langdon, "that was something else you did not notice when you made your inspections."

Bromley replied, "It is the same thing."

Dr. Cotnam put a final question to the witness, "Why did the bridge fall down?"

"The falsework collapsed," Bromley replied, "I can't say why."

from Report

The Contractor had prepared plans for the falsework for PTN3 and PTS3 and had submitted these for the approval of the Engineer. Due to site conditions it became necessary to revise these designs to eliminate timber piles and to substitute temporary concrete spread footings for the support of the falsework. There were several designs submitted for approval and discussed with the engineer. Throughout the negotiations the engineer passed comment upon the structural adequacy or otherwise of the falsework and during February, 1966, sent a letter to the Contractor approving drawings showing piled supports and horizontal diagonal bracing at two levels in the longitudinal direction. Subsequently, these drawings were revised and drawings issued to the field by the contractor as approved construction drawings. These latter drawings revised the supports to spread footings and eliminated the longitudinal diagonal bracing.

The Contractor was of the opinion that these latter drawings replaced the originally approved design whereas the Engineer considers them as supplementary to the original design. Were the new drawings to have been given new drawing numbers rather than been issued as revisions to the original, there would have been no misunderstanding. It is common practice in Canada to consider as void all previous issues of a drawing once it has been revised and

reissued showing a revision number. Thus is appears that the Engineer was of the opinion that he had approved a design showing some longitudinal diagonal bracing and the Contractor believed the latest revisions showed all details of the approved falsework.

Had the Engineer been concerned with this he could have commented on the changes while the falsework was being erected under his supervision, but there is no record of his having done so. The Engineer reminded the Contractor on several occasions that he, the Contractor, under the terms of the contract, carried full resonpsibility for the adequacy of the design of all falsework, though he appears to have accepted a moral obligation to ensure a properly designed falsework. This procedure is quite normal in local engineering practice.

from Citizen

James McNair, with a lien towards lengthy speech making, and who is Officer in charge of Safety, Construction Branch of the Ontario Labour Department, engaged in a lively debate with Dr. Cotnam about the requirements of a safety inspector.

His departmental inspectors, save those in Northern Ontario, have not the power to enforce the safety acts except in rare cases, he said. It was their function to go about with municipal safety inspectors, offering advice and assistance. This was the case, he said, when his Ottawa man, Robert Kerr, inspected the Heron Road Bridge with City Inspector Oswald Andrew. Kerr had no power, Mr. McNair said, to issue such things as "Stop Work Orders," but Andrew did have that authority.

McNair was totally unable to see anyting wrong or unusual with the fact that two inspectors had failed to notice the absence of diagonal longitudinal bracings. McNair said, "I can think of no better or safer construction than having falsework designed by professional men and then having those professionals on the job."

Mr. Langdon roared, "Will, it didn't work out that way in this case, did it?"

"The bridge fell down, yes, and that is why it was such a shock for me when it happened," replied the Safety Official. On hearing that neither inspector Kerr nor Andrew were qualified engineers, Dr. Cotnam asked whether it would not be better if all inspectors should have such qualifications. McNair replied with an emphatic no. He said where engineers were on the job they were in a position to advise the safety inspectors regarding safety or otherwise advise the project.

"Then," said Dr. Cotnam, "if this be so we might as well dispense with safety inspectors altogether. It that what you imply."

McNair smiled broadly and considered the question a moment before replying, "Well, it's a target to consider." McNair then went on to say that the two inspectors in this case, in fact, had pointed out certain safety regulations all of them minor ones - at various times. These infractions had been corrected.

Dr. Cotnam remarked, "Then what you are saying is that the only thing the inspectors are doing is looking for minor infractions."

The witness said no that this was not quite true. "Only recently has an inspector issued a "Stop Work Order" elsewhere in Ontario, but I cannot discuss it here because the case is still in progress."

Roland Loetan, senior inspector for the Dillon Company, was the last witness to testify Wednesday.

He said to his knowledge, there was never any other plan than those approved by Mr. Bromley, used in the construction of the falsework. He said it was his duty to see that the falsework was constructed in accordance with the plan and that he was not aware of the absence of the bracing and that he was not concerned about their absence.

November 24, 1966 from Citizen

Fail To Make Report On Bridge Bracing

William Trischuk, Civil Engineer with the City and the Supervisor of Construction Safety, admitted reluctantly that one of the inspectors, Oswald E. Andrew, had done nothing about it when he noted the absence of required diagonal longitudinal bracing on the falsework of span 3S which ultimately collapsed.

Under probing examination by a Crown Counsel, Herbert Landgon, Mr. Trischuk attempted to explain away Andrew's failure to act by insisting that Andrew had, in fact, been given assurance that everything was all right by a competent person. The competent person the witness was referring to was 22 year old Richard Brock, instrument man on the job. However, under continuing questioning, Mr. Trischuk blindly admitted that Andrew should have taken the problem to him (Trischuk) if there was any doubt.

Safety Inspector, Oswald Andrew, told the inquiry that he had gone to the bridge site with Ontario Safety Inspector, Robert Kerr, on June 6. Someone in the office called and said that none of the senior engineers were available to take the inspection and that Brock was in charge.

from Journal

Andrew said that at the time of his visit he had expressed concern about the size of the main posts in the falsework. "I asked Mr. Brock if the mathematical calculations had been checked out by professional engineers. Brock replied that they had been checked by three enginerrs."

Andrew was asked by special Crown Counsel if he recalled a statement made to police after the disaster about the absence of diagonal bracing in a longitudinal direction.

"Why didn't you tell us about the bracing today," asked Mr. Langdon.

"I don't know," he replied.

"Why did you omit the absence of bracing from the evidence, did it slip your mind?"

"I will have to say I was waiting for you to question me," said Mr. Andrew.

from Citizen

Obviously reluctant to make the admission, Andrew told Mr. Langdon that on more than one occasion he had been instructed by his superior, W. Trischuk,

that in as much as he was not a professional engineer, he was not to express any opinion on his own when he was dealing with professional engineers on a construction job. Mr. Langdon asked when Andrew received his most recent instruction to that effect. The witness replied "only last might."

The surprising answer caused supervising coroner, Dr. H. B. Cotnam, to spring forward in his seat. He wanted to know all about the previous night's call. "How did he (Trischuk) happen to call you last night?" the presiding coroner asked.

"Just to remind me that I am not a professional engineer," said Andrew.

"Did he attempt to intimidate you, or did he discuss with you the evidence you were to give today?"

"No, no, no," replied Andrew quickly.

Dr. Cotnam said coldly, "It strikes me as amazing that he would call you last night just to tell you again that you weren't a professional engineer." Andrew shrugged but made no reply.

Robert Kerr, Ottawa area safety inspector for the Ontario labor department, admitted that he made no report to his superiors after he had noticed a lack of diagonal longitudinal bracing at the Heron Road site when he went there with Andrew.

And, he said, he had also been instructed that since he wasn't a professional engineer, he must not question trained engineers in making his inspections. His instructions had come from R. K. Cleverdon, assistant chief of the labor department's construction safety branch.

Cleverdon, himself, who testified in long, uninterrupted bursts with machine-gun rapidity, said his instructions to Kerr had not been "quite that way." What he meant to impart to Kerr was that in cases where Kerr was in doubt about some safety matter, he was not to argue with the job engineers, but was to report to Toronto at once. "Our inspectors are told only that since they are not professional engineers they must not attempt to practice the profession. They are told that when doubts arise they are to get in touch with us."

"And," asked Mr. Langdon, "did Kerr ever make any report to you about his doubts over the Heron Road Bridge falsework?"

"No, not that I can recall," replied Mr. Cleverdon. He said: "The contractors have the responsibility for the construction. How they get the thing up there is their responsibility." Consulting engineers have some responsibility for the designs, but in the main the responsibility rests with the contractor, Cleverdon felt.

Mr. Cleverdon compared the relationship between safety inspectors and engineers as that of a nurse to a doctor. "It would be the same thing as a nurse suggesting to you how to perform an appendectomy," he told Ontario Chief Coroner Dr. H. B. Cotnam. "This inquest may feel that your policies are wrong," said Mr. Cleverdon, "but they are not Mr. Andrew's and they are not mine. I think Mr. Andrew did a remarkable job."

from Journal

He added that it was his opinion the department policies are basically correct, adding that there were four engineers on the job, none of whom questioned the falsework.

"Are you suggesting a method of policing the engineering profession," asked Dr. Cotnam.

"I don't think I should comment on that," he replied.

The question of qualification for safety inspectors had popped up on several occasions during this inquest.

from Citizen

Testifying at the inquest, three experts said that some of the support lumber used in the bridge falsework was substandard and of poor quality, consisting mainly of white or red pine, and a bit of hemlock.

B E. Kennedy, head of the timber-mechanics section of the federal forestry and rural development department, summed up the picture. "There may always come a time when you have a set of circumstances wherein a structure is weakened. This is where lumber can become a very vital and important feature. In the Heron Road Bridge instance, I feel that if everything else had been as it should have been, a proper grade of lumber might have stood up. It is an utmost necessity that lumber should be properly graded if it is going to be used in construction with constant success. Kennedy said that wooden columns in the falsework were below the average in pressure strength and so was their "elasticity value."

"It was obvious," said a second expert, former federal director of forestry research, John H. Jenkins, that some samples of the wood examined by him were "not structural." He found that some "good quality" spruce was used for the two-by-six braces, but only about 25% of that could be considered of "structural" quality.

Special Crown Counsel, Herbert Langdon asked, "Do you agree with this practice in construction?"

"No, I certainly do not," Jenkins replied. "All of the research work we are doing from coast to coast is based on proper grading." He said there is no government regulation on the grading of construction lumber. W. A. Ouellette, a licensed grader, said he accompanied Jenkins to the bridge collapse site. He agreed thoroughly with the views stated by Mr. Jenkins.

Morris Miller, of Barrie, Ontario, a lumber dealer who supplied some 1,623 pieces of lumber for the Heron Road Bridge falsework, said that the contractors, O. J. Gaffney and Company, had ordered spruce or red pine. But he had been able only to furnish about 15% spruce. Almost all of the lumber sent to the bridge site, except "maybe about 100 to 150 pieces, were freshly cut." "It was fresh from the stump," he said. Miller said he believed the lumber he supplied was for posts only. The timber was not graded, and was quite green," he recalled. It is the general practice in the industry not to furnish graded lumber for construction purposes, he said, except for fine work such as finishing interiors where top grades were required.

Told To Shut Up

November 25, 1966
from Journal

A Gaffney Construction Company laborer told the Heron Road Bridge inquest today he had questioned on eight occasions the adequacy of the falsework which collapsed and on the ninth time he was told he would be fired if he asked again.

Mr. Charette spend several weeks in hospital and later in Rehabilitation Centre in Toronto recovering from the injuries he received in the collapse. He said he had questioned the government engineer, whom he could not identify by name or description, about the bracing in the falsework eight times and was told, "If you tell me that once more you will be fired."

Asked why he stayed on the bridge if he knew it was going to fall down, Charette replied, "Because I needed my salary like everyone else and I trusted the engineers."

He said he was told by 6 or 7 engineers whom he couldn't identify that the falsework was safe. He also said he had seen a bucket loaded with concrete hit the bridge twice at 9:30 a.m. and again at 2:30 p.m., about an hour before the bridge collapsed.

from Journal

The Heron Road Bridge inquest Friday was shown a graphic demonstration of how the collapse of the span August 10th could probably have been avoided. Using two models, both 36 inches high with one lacking adquate bracing, Professor C. F. Morrison, of the University of Toronto, demonstrated how accurate bracing in falsework will redistribute a load. (Exhibit I).

The first model used was built simply of 5 vertical posts which did not include bracing. It collapsed under a weight of from 96-104 pounds. The second model built exactly the same as the first, only including bracing on the vertical posts continued to stand up under weight of 224 pounds. Professor Morrison said the second model would carry about 500 lbs.

As he added weight to the first model it became clear that without the bracing the main posts began to bend and buckle until the model finally gave way. In the second model only the centre post buckled slightly. He said a structure with the type of bracing shown in the second model has about four times the load carrying capacity as the one without it. He also said one weak post would not necessarily cause a structure such as the second model to collapse.

from Journal

One of the designers of the falsework for the span of the Heron Road Bridge scrubbed diagonal bracing from the final design because he considered it unnecessary.

Robert McTavish, chief engineer of John Galfney Construction Company, an affiliate of O. J. Gaffney Company, builders of the bridge, was recalled to testify at the inquest Friday.

He said the diagonal bracing in the longitudinal direction had been incorporated in the previous design to compensate for windload on the falsework. Mr. McTavish went on to explain it had been dropped from the final approved design because another system had been incorporated as a substitute.

But the other system was absent from the final plan, and he told the inquest he had failed to notice the absence when he approved the plans and did not notice the absence of the system when he visited the site when the falsework was under construction.

Mr. McTavish said he tried to explain to Victor J. Bromley, Project engineer for the M. M. Dillon Company, in a telephone conversation, that the diagonal bracing was not necessary. He explained he eventually had to make a trip to Ottawa from his company's head office in Stratford to convince Mr. Bromley the bracing was not needed in that particular design. He said Mr. Bromley finally approved the design. But the Dillon engineer who testified Thursday, and who had approved for his consulting firm the final plans of the falsework, denied Friday he had approved the absence of the supports in question. "I wish to say that at no time did I approve of the removal of diagonal bracings from the falsework," he said, after specifically requesting permission to make a statement.

Mr. McTavish told the inquest "the span fell down because we did not have the support in the longitudinal direction as we thought we did have." He said he did not notice the absence of diagonal bracing when he visited the site because "I was specifically interested in something else."

November 29, 1966
from Journal

Chief engineer, Victor Bromley of M. M. Dillon Company, failed to give a valid explanation of his part in the faulty design of falsework for the Heron Bridge, Coroner H. B. Cotnam said today.

Dr. Cotnam spoke today for about an hour before 5 jurors were required to consider their verdict. The jury was expected to report back this afternoon.

Dr. Cotnam, Ontario supervising coroner, said it was the jury's duty to speak for the dead and to protect the living. It was assembled primarily to seek the cause of death of bridge foreman Clarence Beatty and at the same time establish the reason for the bridge collapse.

He recalled evidence of the changes in plans for the falsework and that Dillon Company engineers rejected two of the designs of O. J. Gaffney Company of Stratford. Dillon had approved a third set of plans which was later changed.

Dillon provided the consulting engineers for the project. Dillon officials said they believed the 4th set of plans was an amendment to the 3rd set. Dr. Cotnam said other evidence showed that by standard engineering practice, the 4th set replaced all others. It seemed nonsensical to him that consulting engineers can suggest changes in falsework or veto it and yet escape responsibility for any defects. In the light of the established engineering practice he could not accept Mr. Bromley's evidence that he had not approved final plans for the falsework.

The jury might consider recommending that all multitier falsework carry the stamp of the professional engineer and that this engineer take final responsibility for the falsework. They might also consider recommending the licensing of contractors, safety inspectors, professional engineers, and that timber used for falsework be graded.

Verdict Text

November 30, 1966
from Journal

We the jury find that Clarence Beattie, age 35, died at the site of the Heron Road Bridge, City of Ottawa, County of Carleton, on the tenth day of August, 1966, at approximately three hours, twenty seven minutes, twenty two seconds P.M. Eastern Daylight Time.

We find that his death was caused by a crushing injury to the chest. These injuries were due to the failure of the falsework and subsequent entanglement in steel bars and cement. Further, the falsework failure was due to the lack of bracing in the diagonal longitudinal direction.

In the light of the evidence presented, we are of the opinion that the failure of the falsework was caused by:

1. Lack of experience on the part of the contractor in falsework designs of this size.

2. Too great a dependence on the assumed similarity between the Rogue River Bridge and the Heron Road Bridge, span PTS3.

3. Inadequate bracing of the falsework on the diagonal longitudinal direction. Notwithstanding the fact that the contract appears to place the responsibility on the contractor, we feel that the consulting engineering firm should bear some of the responsibility for failure of the falsework. We are of this opinion as the result of the engineers having suggested and approved changes in the falsework design.

We the jury recommend:

1. A clear definition be set out in all contracts defining the responsibilities of the contractor and the consultant engineering firm.

2. It shall be the responsibility of the contractor to ensure that material purchased shall be in compliance with that specified on the falsework drawings. If the falsework design calculations have been carried out on a specific grade of material which is not available at the time of construction, additional calculations should be carried out.

3. That safety inspectors make a written report on any area of the falsework which in their personal opinion they consider to be inadequate.

4. That safety inspectors be given the opportunity, through training courses, of increasing their technical knowledge and ability. And further where bridge construction is involved we would recommend that the safety inspectors supervise or take a greater direct interest in the bridge construction.

5. Graded lumber be used in the construction of falsework and that it be graded in accordance with a recognized standard.

6. A code be developed to deal with various aspects concerning bridge, culvert and falsework construction and that this code become a mandatory requirement of bridge, culvert and falsework construction in the province of Ontario. We would strongly suggest that this be carried out as quickly as

possible. A study be made into the weight bearing load of bridges in the light of increased loads being carried on our highways today. The results of this study to be incorporated into the mandatory code.

7. If current legislation does not require that signs be posted on bridges limiting the maximum safe loads, we would recommend that this be done.

8. A requirement that approved design and construction drawings for multitiered falsework carry the stamp of a registered professional engineer (civil).

from Journal

Coroner H. B. Cotnam congratulated the jury on its excellent verdict and commended it for spending 10 hours and 48 minutes before rendering a verdict. He said it was at least an Ontario record for an inquest jury to ponder a decision and may be a Canadian one. The hundred thousand dollar cost of the provincial investigation into the collapse also was a record he said.

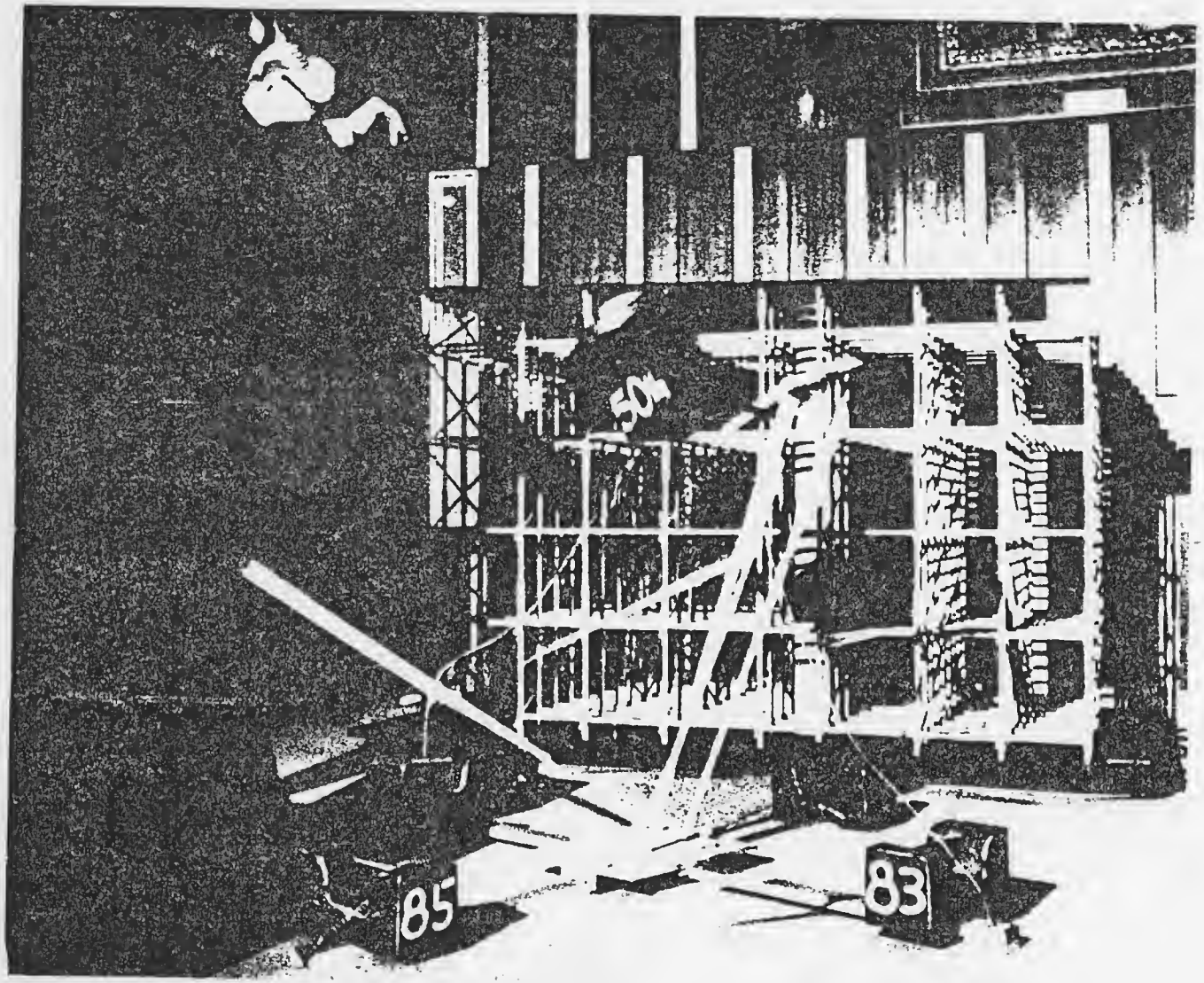


Exhibit C-1. Professor C. F. Morrison, University of Toronto, demonstrating before the Coroner's Inquest how inadequate bracing of falsework caused the collapse. *(From U.P.I.)*

HERON ROAD BRIDGE CASE

Think Questions

PART C

1. What is normally the purpose of a coroner's jury? Was this the sole purpose in this case?
2. Should other than qualified engineers have been permitted to give opinions on the adequacy of the falsework?
3. Why were the longitudinal cross bracings ommited?
4. With respect to how drawing changes were made, do you feel that the error made was due to negligence?
5. Should the consultant engineer check all calcuations made by the contractor?
6. Should the contractor be held responsible if the consultant engineer has not checked the calculations?
7. How do the educational levels of the people involved in the construction firm compare with their responsibilities?
8. Did Brock perform functions normally expected of an engineering summer student?
9. What should be expected from safety inspectors?
10. Should Bromley have made his admission?
11. Is the reliance of the inspection agency on the work of professional engineers misplaced?
12. Should graded lumber be used for falsework in construction?
13. Why did Professor Morrison state that in the braced model "one weak post would not necessarily cause the structure to collapse?
14. What criminal or civil action would you expect as a result of the coroner's inquest?
15. Discuss the verdict item by item as to their merit and possibility of implementation.
16. This case happened in Ottawa, Ontario, Canada. Could it have happened in your area? Why?

ENGINEERING CASE LIBRARY

ECL 133D

HERON ROAD BRIDGE (D)

Part D of this case summarizes actions resulting from the investigation. The contractors were found guilty of negligence and fined by the City Magistrate's Court, and three engineers employed by the contractor and consultant were suspended by the Association of Professional Engineers of Ontario.

 Prepared for the Stanford Engineering Case Program by Geza Kardos, Associate Professor of Mechanical Engineering, McMaster University, Hamilton, Ontario, Canada, with the support of the National Science Foundation.

HERON ROAD BRIDGE (D)

January 15, 1967 *from Citizen*

Two charges were laid by the City today against O. J. Gaffney Construction Limited in connection with the Heron Road Bridge collapse. O. E. Andrews, City Contractor Safety Inspector, swore out charges again before Justice of the Peace, Desmond Mologhy. Charges under the Construction Safety Act of Ontario, charged the company, which did the general contracting job when the collapse occurred, with failing to brace the structure in a safe manner in order to support the pouring of concrete and failing to provide diagonal bracing. Summons were issued ordering the company to appear in City Magistrate's Court, January 22, 1967.

Gaffney fined $5,000 in collapse *March 4, 1967*

O. J. Gaffney Construction Company of Stratford, was prime contractor on the ill-fated Heron Road Bridge span which collapsed. The firm pleaded guilty February 16, to a charge for failing to provide sufficient bracing and supports in construction of falsework. The fine assessed by Magistrate Carter was the heaviest that could have been levied.

"It is obvious that the maximum penalty must be imposed," he said. Counsel for Gaffney argued for the imposition of less than the maximum fine as the judicial recognition that Gaffney shared responsibility for the collapse with the consulting engineers on the project even though they could not be charged under existing legislation.

The collapse had occured as a result of an honest mistake, nothing more, nothing less, he said. Mr. Spooner recalled that the falsework had been an evolution of several plans and had been inspected by the consulting engineers with corrections recommended by them made. He said the Gaffney firm had no previous convictions under the construction safety act and should be treated as a first offender by the court. The maximum fine should only be assessed when there is repeated flagrant violation of safety regulations maintained.

City Counsellor Donald Hambling said there had been a negligent act and stressed the only way contractors could have the responsibility they bear to the safety of workmen brought home was through imposing of the maximum penalty.

Magistrate Carter said the investigation into the disaster had left no doubt as to where the responsibility lay. The Magistrate said it was evident to him that construction safety inspectors were overworked and as a result of this an inspection had been made somewhat dangerously cursory.

The Act provides for up to $5,000 fine or twelve months in jail when an individual is involved. The only penalty executed when a limited firm is charged is the fine. In his chambers after the case was completed, the Magistrate said if the company officials were faced with the prospect of a jail term they would likely pay strict attention to the enforcement of safety regulations in the future. *from Citizen*

from Digest

Special Board of Inquiry Reports

Involved in the Heron Bridge disaster were the contracting firm of O. J. Gaffney Limited and the consulting engineering firm of M. M. Dillon Limited, both organizations being headed by and employing professional engineers who are members of the Association of Professional Engineers of the Province of Ontario.

The Association of Professional Engineers of the Province of Ontario established its own Special Board of Inquiry with W. H. Arison, P. Eng., as Chairman, and with Messrs. J. T. Gregg, P. Eng., and A. B. Connelly, P. Eng., as members thereof. The objectives of the Board were to review all reports and data available from other investigations and to undertake such additional investigations as it might consider necessary, all for the prime purpose of determining the suitability of the actions, the practices, the professional conduct, and the competence of members of the association involved in the design, construction and inspection of the Heron Road Bridge. The Board was specifically instructed not to make findings concerning the technical reasons for failure but to restrict its concern about technical matters to those instances which reflected directly or indirectly the conduct of members of the association.

The Special Board met seven times in Toronto and Ottawa, reviewed and examined numerous documents and exhibits of all kinds, and considered the parts played by fourteen members of the association in the various aspects of the project. It was the conclusion of the Board that the conduct of three of these members was such as to warrant a formal examination by Council as a whole. Council accepted the recommendations of the Board. Council's decision is shown in Exhibit D-1.

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The Act provides for up to $5,000 fine or twelve months in jail when an individual is involved. The only penalty executed when a limited firm is charged is the fine. In his chambers after the case was completed, the Magistrate said if the company officials were faced with the prospect of a jail term they would likely pay strict attention to the enforcement of safety regulations in the future. — *from Citizen*

LIST OF EXHIBITS (D)

Exhibit D-1:	Decision of the Council of the Association of Professional Engineers of the Province of Ontario	*(from A.P.E.O.)*
Exhibit D-2:	A Brief History of the Association of Professional Engineers of Ontario	*(from A.P.E.O.)*

IMPORTANT NOTICE

IN THE MATTER OF THE PROFESSIONAL ENGINEERS ACT
R.S.O. 1960, CHAPTER 309, SECTION 28

AND IN THE MATTER OF VICTOR J. BROMLEY
ROBERT J. McTAVISH, AND BERNARD J. HOUSTON,
MEMBERS
OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE
PROVINCE OF ONTARIO

DECISION OF THE COUNCIL OF THE
ASSOCIATION OF PROFESSIONAL ENGINEERS OF
THE PROVINCE OF ONTARIO

A special meeting of Council of the Association, held at its offices, on Wednesday, December 6th, 1967, considered certain complaints against Victor J. Bromley, Robert J. McTavish, and Bernard J. Houston, all being members of the Association of Professional Engineers of the Province of Ontario.

These complaints were:

That Victor J. Bromley was guilty of gross negligence or incompetence or unprofessional conduct as defined in The Professional Engineers Act, R.S.O. 1960 Chapter 309, Section 28 (1), and as further defined in Regulation 196, Section 16. Victor J. Bromley was the project engineer of M.M. Dillon Limited, consulting engineers, on the construction of the Heron Road Bridge in the City of Ottawa. He was employed in such a capacity that he assumed the main personal responsibility for general supervision and on behalf of his employer, he was designated as the authority for the approval of falsework designs advanced by the contractor.

That Robert J. McTavish was guilty of gross negligence or incompetence or unprofessional conduct as defined in The Professional Engineers Act, R.S.O. 1960, Chapter 309, Section 28 (1), and as further defined in Regulation 196, Section 46. Robert J. McTavish was the newly appointed Chief Engineer of O.J. Caffney Limited, the contractor for the construction of the Heron Road Bridge in the City of Ottawa, and as such he was responsible for and supervised certain portions of the design of falsework, initiating certain revisions to the original design of the falsework.

That Bernard J. Houston was guilty of gross negligence or incompetence or unprofessional conduct as defined in The Professional Engineers Act, R.S.O. 1960, Chapter 309, Section 28(1), and as further defined in Regulation 196, Section 46. Bernard J. Houston was employed by O.J. Caffney Limited to undertake falsework design and to perform other duties, and in this case he was responsible for making the calculations for the falsework and for checking the drawings produced from his calculations, which were in turn to be used in the construction of the falsework for the Heron Road Bridge in the City of Ottawa.

By consent of counsel for the three members, the hearing of all three complaints was held jointly, and all evidence heard was received with respect to all three members. Counsel for each member was permitted accordingly full right of cross-examination of all witnesses called in support of the complaints, or called by counsel for either of the other members under examination.

At the commencement of the hearing, counsel for Bromley made a formal objection to the proceedings, alleging that by virtue of Section 35 of The Professional Engineers Act, Chapter 309, R.S.O. 1960, and the time limit stated therein, Council could not proceed in the matter of the complaint against Bromley. This formal objection was also made by counsel for McTavish and Houston. Council ruled that Section 35 of the Act is not applicable to disciplinary proceedings initiated by the filing of a complaint, and accordingly that Council does have jurisdiction in the matter.

The formal complaints which initiated the hearing were read, as was a lengthy document entitled "Agreed Statement of Facts", being largely extracts from the report of H.G. Acres and Company Limited made for the Supervising Coroner of Ontario, and being accepted (with certain reservations) by counsel for Messrs. Bromley, McTavish and Houston. Oral evidence was given by three consulting engineers by Victor J. Bromley, by Robert J. McTavish, and by Bernard J. Houston. All parties named in the complaint were represented by counsel and were given full opportunity to make submissions and to cross-examine witnesses.

VICTOR J. BROMLEY

As project engineer for M.M. Dillon Limited, consulting engineers, Victor J. Bromley's responsibilities were varied, but did include certain specifics by virtue of the terms of the agreement between the City of Ottawa and M.M. Dillon Limited, as outlined in paragraphs 1(e) (iii) and 1(e) (iv) as follows:

"1(e) (iii) Provide general supervision, including the approval of shop drawings and furnishing of related advice and correspondence, together with all matters normally related to these functions, and furnish a report to the Director in respect to all tenders.

1(e) (iv) Make regular visits to the site of the work as its scope requires and provide field supervision of construction of the work, including guidance, assistance and supervision to resident engineers, inspectors and contractors, to ensure that execution of the work is in accordance with plans and specifications therefor, check all progress and completion certificates prepared by the resident staff and certify amounts for payment in respect thereto, submit to the Director monthly, or as otherwise specified, during the progress of the work completed to date; assist in placing the completed work in operation; and generally undertake all responsibility in matters normally related to consulting engineering field supervision."

A series of drawings depicting various designs of falsework were introduced into evidence, together with associated correspondence between consulting engineer and contractor. These data described the evolution of two basic designs by the contractor, and included the suggestions, requests and approvals of Victor J. Bromley. Up to the date of February 18th, 1966, there appears no question as to the suitability or otherwise of the designs nor as to agreement or otherwise of

Exhibit D-1. Decision of the Council of the Association of Professional Engineers of the Province of Ontario

Bromley in falsework designs put before him. Indeed, two expert witnesses called by the complainant both gave opinions to the effect that had the falsework been constructed in accordance with the drawings approved by Bromley in his letter of February 18th, 1966, a collapse would not have occurred.

No sooner had this approval been given, however, than the contractor's representative, Robert J. McTavish, held discussions with Bromley as to further changes, due to difficulties arising with foundation conditions. At a meeting on February 23rd, 1966, changes from shoot piles to spread footings were discussed, as were substitutions for the longitudinal horizontal diagonal bracing approved in Bromley's letter of February 18th, 1966.

Evidence given by Bromley indicated that the conclusion of this meeting would lead to a further submission of drawings by the contractor, showing modifications of the footings. However, evidence given subsequently by McTavish and supported by his own notes, made at that time, indicated that he left the meeting under the impression that the longitudinal horizontal diagonal bracing could be deleted.

Revised drawings dated March 18th, 1966, were submitted to Bromley as the outcome of the meeting referred to earlier. These drawings showed a conversion to concrete pad footings and did not show the longitudinal horizontal diagonal bracing which appeared on the earlier version. Bromley approved these drawings by letter dated March 28th, 1966, with some exceptions which are not relevant to the hearing, and subsequently approved, in his letter of April 18th, 1966, the final drawings which incorporated the exceptions to which reference was made previously.

Bromley's evidence indicated that he believed that the 'final' drawings approved by him were supplemental to, and should be read with the earlier versions which contained the bracing, and that his approval was in fact restricted to the footing details, and other minor points. He reiterated upon several occasions during his testimony that he fully expected the design of the falsework to include longitudinal horizontal diagonal bracing, as depicted in the earlier version.

Evidence given by two experts, however, made it clear that the concept and the detail of the final drawings were quite different from concept and detail of the earlier version, that in fact the two sets of drawings were incompatible, and finally that the latest set approved by Bromley was sufficiently complete to be used for construction - and it was in fact so used.

Upon being questioned as to his responsibilities for supervision of construction, Bromley stated that he was present at weekly site meetings for several months up to the time of the collapse. He admitted that he did not notice the absence of longitudinal horizontal diagonal bracing in the finished falsework.

On the matter of detailed inspection of the falsework, Bromley reported that Mr. T.L. Baird, P.Eng., subsequently killed in the collapse, had made such an inspection, and had provided him with a list of more than one hundred deficiencies, some said to be minor, some said to be serious. However, the absence of longitudinal horizontal diagonal bracing was not mentioned.

In reviewing all of the evidence before it, including the opinions of expert witnesses, the design drawings, and the correspondence, Council observes that Bromley's performance as project engineer was thorough and workmanlike, and that he displayed far greater than usual interest in falsework - up to and including the February 18th, 1966, approval by him. Council is unable to understand Bromley's subsequent approval of revised drawings on April 18th, 1966, and particularly his inability to recognize that these were, in fact, replacement drawings and not supplements to those approved on February 18th, and concludes that Bromley displayed a lack of engineering skill in so doing.

In respect of Bromley's responsibilities for supervision of construction, Council has noted his weekly attendance at the site for the purpose of ensuring that the work was constructed in accordance with the plans and specifications, and has noted also his substantial and proper concern for adequate bracing up to the approval date of February 18th, 1966. Council further notes that lack of communication and uncertainty concerning responsibilities for design and construction of falsework was present in this instance, and indeed appeared to characterize the construction industry, that despite the earlier protestations, construction of the falsework was permitted to proceed without the necessary longitudinal horizontal diagonal bracing, and that Bromley failed to notice the absence of that bracing which is acknowledged to be the cause of the failure. Council, as a consequence, concludes that Bromley did not exercise proper judgement in the discharge of his duties related to supervision of construction.

In recording such serious deficiencies in two aspects of Bromley's duties, Council finds that the defendant, Bromley, failed to exercise the ordinary skills of a professional engineer in respect of his assignment on the Heron Road Bridge, and accordingly finds Bromley guilty of incompetence, as defined in Section 16(c) of Regulation 496 under The Professional Engineers Act.

As a result of this finding and by virtue of the powers vested in it by Section 28 of The Professional Engineers Act, Chapter 309, R.S.O. 1960, it is the decision of Council that the membership of Victor J. Bromley in the Association of Professional Engineers of the Province of Ontario is hereby suspended for a period of 12 months, as of the date of communication of this decision.

ROBERT J. McTAVISH

In his evidence, McTavish dealt at some length with his employment by Gulliver since 1962. In 1965 he had made proposals designed to reduce confusion and to provide better definition of responsibilities and authorities, suggesting that the operation be departmentalized. Under such an arrangement, he would become Chief Engineer, Mr. B.J. Houston Chief Estimator, and Mr. J.H. Hallam Construction Manager.

McTavish acknowledged that he participated in the development of the falsework design scheme, approved by Bromley in his letter of February 18th, 1966, that he had received Bromley's suggestions (his drawing S-36A), and that he had understood these to be related to bracing against transverse wind loads.

McTavish stated further that he had proposed transverse bracing of individual bents against wind loads, that he understood Bromley to have agreed to the bracing of the bents, and that the longitudinal horizontal diagonal bracing could, therefore, be deleted. On the basis of this understanding, a revised design was prepared, was submitted to Bromley for approval - and was so approved by Bromley's letters of March 28th, 1966, and April 18th, 1966.

Asked whether the final approved drawings were sufficiently complete as of themselves for construction purposes, McTavish replied 'yes'. Asked whether he still considered the final design to be suitable for use, he replied 'yes'.

McTavish gave further evidence to the effect that he visited the site on June 2nd, 1966, and had the opportunity to view the then nearly completed falsework. He did not notice any deficiency in the bracing at that stage. Upon cross-examination by J.H. Francis, McTavish acknowledged that he did not notice the bracing deficiency in the three outside rows of falsework and that his design review had not recognized the fact that the bridge piers did not extend for the full width of the bridge. He further stated that the final drawings, as approved on April 18th, 1966, were considered by him to stand on their own feet, and to be used without reference to earlier versions.

Questioned again concerning his meeting with Bromley, McTavish reiterated his conviction that the elimination of the longitudinal horizontal diagonal bracing was agreed to, that he did not feel the elimination of this bracing was a major change, and further that the vertical x bracing of each bent took care of the wind load requirement.

Questioned about the statement that he had allowed unstamped unsigned falsework drawings to be issued to the field, McTavish replied that this was the normal practice of his organization, and common throughout the industry.

In reviewing the evidence before it, including that previously given by Bromley, Council observes that McTavish worked in an environment in which his personal responsibilities and those of his colleagues were very much in doubt. It further observes that technical and operational communications between McTavish, as the responsible technical representative of the contractor, and Bromley, as the responsible technical representative of the consulting engineer, were unbelievably poor, and were undoubtedly the principal cause for the misunderstandings which ended so tragically.

Regardless of the foregoing, however, Council must conclude that McTavish did not properly discharge his responsibility to produce a design for falsework which was sufficiently complete in itself to permit its construction without relying on the judgement of field personnel, which would be adequate to withstand all loads likely to be imposed upon it, and which would ensure the safety of all persons connected with the work. He approved a design which failed to provide bracing suitable to ensure stability of the falsework configuration, and he apparently confused the requirements for wind resistance with those for horizontal stability.

For these reasons, Council finds that the defendant, McTavish, failed to exercise the ordinary skills of a professional engineer in respect of his responsibilities on the Heron Road Bridge, and accordingly finds McTavish guilty of incompetence, as defined in Section 46(c) of Regulation 496 under The Professional Engineers Act.

As a result of this finding, and by virtue of the powers vested in it by Section 28 of The Professional Engineers Act, Chapter 309, R.S.O. 1960, it is the decision of Council that the membership of Robert J. McTavish in the Association of Professional Engineers of the Province of Ontario is hereby suspended for a period of 12 months, as of the date of communication of this decision.

BERNARD J. HOUSTON

Evidence indicated that Houston became associated with the Gaffney organization in early 1964 and that his duties were, primarily, those of 'estimator', but that he also engaged in the design of falsework or temporary structures for his firm. He stated that he had made designs for fifteen temporary structures before becoming engaged in the Heron Road Bridge project. The highest structure with which he had been connected up to that time was 30 feet.

In answer to questions, Houston stated that he had done the calculations for the initial version of the falsework design, and that he had checked the drawings themselves after their preparation by one Egert.

Houston acknowledged being a part of discussions centering around Dillon drawing S-36A. He stated that the longitudinal horizontal diagonal bracing requirement was incorporated in the Gaffney drawings which were approved by Bromley on February 18th, 1966. Houston further indicated that he assisted in revisions to the design concept, to the calculations, and to the drawings subsequently to McTavish's meeting with Bromley, and all as instructed by McTavish. Design calculations were said to have been checked by McTavish.

Upon cross-examination, Houston stated that the final drawings were prepared under his direct supervision by Richard H. Brock, a student in second year civil engineering, but that he (Houston) was prepared to take full responsibility for them. Upon a further question, he expressed the opinion that the final construction drawings, as approved by Bromley March 28th, 1966, and April 18th, 1966, were somewhat deficient in detail, it normally being assumed that field decisions could compensate for this.

Houston indicated that his design calculations were checked by McTavish, and that the drawings were similarly checked. They were issued to the field without stamp, signature or initial as that was the practice in the organization.

In considering evidence presented by and on behalf of Houston, Council reiterates its observation that Houston did his job in an environment in which his personal responsibilities were ill-defined and often in doubt. However, he did acknowledge having made various designs and modifications, generally under the direction or upon the instructions of McTavish.

Council further observes that these design calculations appear to have been made - and converted into drawings - with perhaps some defect in detail, but without defect in principle, up to and including those approved by Bromley's letter of February 18th, 1966. However, after that date, it appears that Houston accepted without question instruction from McTavish which resulted in an unsafe design. While Council recognizes Houston's subordinate position in this instance, his failure to inform his superior and other appropriate parties of the defects of the final design must be considered to indicate his lack of knowledge of the engineering principles involved or his rejection of his responsibilities as a professional engineer.

For these reasons Council finds that the defendant, Bernard J. Houston, failed to exercise the ordinary skills of a professional engineer in respect of his responsibilities on the Heron Road Bridge, and accordingly finds Houston guilty of incompetence as defined in Section 46(c) of Regulation 496 under The Professional Engineers Act.

As a result of these findings, and by virtue of the powers vested in it by Section 28 of The Professional Engineers Act, Chapter 309, R.S.O. 1960, it is the decision of Council that Bernard J. Houston receive an official reprimand, and the fact of this reprimand be recorded in his official record.

For the Council of the Association of Professional Engineers of the Province of Ontario.

Dated this 20th day of December,
1967, in the City of Toronto,
in the Province of Ontario.

Gerald B. Waterman, P.Eng.,
President.

(5) A Brief History of the Association of Professional Engineers of Ontario (A.P.E.O.)

Shortly after World War I, Ontario engineers began to concern themselves about the possibility of forming a professional entity to include all professional engineers. Six organizations lent their support to this feeling, and sent representatives to the first meeting held on March 13th, 1920, to discuss the possibility of securing legislation to govern the engineering profession. The six organizations were:

A.I.E.E.	–	The American Institute of Electrical Engineers
C.I.C.	–	The Chemical Institute of Canada
C.I.M.M.	–	Canadian Institute of Mining & Metallurgy
E.I.C.	–	The Engineering Institute of Canada
O.A.M.	–	The Ontario Association of Architects
O.L.S.	–	The Ontario Land Surveyors

This group of individuals became known as "The Committee," and later, more formally, "The Advisory Committee on Legislation."

Legislation was drafted and an Act to Establish the Association of Professional Engineers of Ontario received its final reading and was passed on June 4th, 1922.

The first meeting of a provisional council took place on August 8th and 9th, 1922, C. H. Mitchell being in the chair. The first annual meeting was held on January 8th, 1923, with 81 members present. The membership was then 854.

The work of the Association for some time was directed to providing some services to the members–and towards revising The Professional Engineers Act–a piece of legislation which was 'open'–it permitted membership but did not require it for practice. It was not until 1937 that the Act was 'closed'–fourteen years and $17,000 were needed to accomplish this! The membership of the Association at that time was 1,260. The profession had now accepted the responsibility for self-regulation on behalf of the Government of Ontario.

In 1948 the Code of Ethics was enacted and prescribed by the Attorney-General. In 1950 the Association moved into its own quarters at 236 Avenue Road, and from a membership of 10,000 began a rapid expansion of membership services.

By 1960 with membership at approximately 18,000, a new Bill, No. 36, was introduced into the provincial legislature–but after a stormy history, in which its passage was frustrated by members of the Association, it was withdrawn. It had become abundantly clear that communication between this large membership and council left much to be desired. This feeling brought about the formation of the chapters of the Association–of which there are now 42.

At the present time, the membership of the Association approximates 24,000 and due to the Chapters and increased committee activity, there are a record number of members involved in the planning and administration of the profession.

The Chapters are assuming an air of permanence as a functional part of the profession, and a wide range of services are being made available to them by headquarters staff.

There are indications of mounting interest and activity in the fields of construction safety, ethics and discipline.

The new, proposed Professional Engineers Act is now in the hands of the Provincial Government and it is possible that this will receive the attention of the Legislature during 1967. In

the meantime, work will commence on the framing of new by-laws to implement the terms of the new Act. Chapters and committees will be taking an active part in this task, particularly with respect to a review of existing terms of reference.

Planned expansions in the Employment Advisory Service have now taken place and it is expected that this will be reflected in increased services to the membership in the current year.

HERON ROAD BRIDGE CASE

Think Questions

PART D

1. Was the fine leveled against the contractors fair? Should it have been less? Should court action have been taken against others?
2. Was the action taken by the A.P.E.O. fair?
3. What is the purpose of a professional association such as the A.P.E.O.?
4. Who should join and why?
5. Did the engineers suspended act in accorance with the code of ethics?
6. Is the code of ethics realistic? Should it be?
7. What do you feel will be the consequences of the action taken on the contractor? the engineers?
8. What responsibility does the employer have toward the engineers?

INSTRUCTOR'S NOTE

HERON ROAD BRIDGE

By G. KARDOS

This case records, through quotation from the press and reports, the failure of the falsework during the building of the Heron Bridge. The case may be used as a focal point to illustrate to the student the legal and moral responsibility of the engineer. The fact that the events take place in Canada should not detract from the utility of the case since the difference between practices in different locales can be studied.

The case may also be used with emphasis on the technical aspects of the failure. Since the falsework collapsed due to the absence of longitudinal bracing, it can be used as a dramatic illustration of the consequences of column failure.

This case is presented in four parts which can be used individually or together; the following outlines the intended use for each section envisioned by the author.

PART A

This section relates the events leading up to the disaster and the subsequent speculation in the press for the failure. The illustration shows clearly the form of the falsework. The student can be asked to speculate as to the reason for the collapse.

PART B

This section of the case is taken entirely from the report submitted to the coroner by consultants. Besides the technical details of the construction and the conclusion and recommendations, it can be used to illustrate to the student what a professional report should contain and present. At this point, the questions of professional ethics can be raised.

PART C

The coroner's investigation reveals the various human factors that led to the collapse. Although the two previous portions have established the technical reasons for failure, the question of how it came about and who is responsible was not resolved. The inquest unfolds in a dramatic way how the situation came about. Of special interest will be the involvement of an engineering student. The focus of this segment can be on professional responsibility.

PART D

The aftermath of the investigation demonstrates the legal action taken against the contractor and the action taken by the Professional Association against the engineers in the case. This provides an opportunity to discuss professionalism and the responsibility of profession to its members and to the public.